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THE REFUGE IN PHEASANT MANAGEMENT

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As early as 1536, according to Leopold (1931), Henry VIII closed an area in what is now metropolitan London to the shooting of pheasants, herons and partridges. Because of its age alone, the refuge in pheasant management is entitled to a degree of respect!

In modern times there has been no dearth of proponents for pheasant refuges. In fact a few states have very largely based their pheasant programs on the refuge, often augmented by the release of game-farm birds. Few, if any, states have entirely eliminated it as a management tool. In many places, refuges established for other species have served incidentally for the protection of pheasants.

In recent years, research findings call to question whether pheasant refuges function as assumed. These findings indicate a need for critical review of pheasant refuges with a view toward properly evaluating their part in the management program.

Only those effects derived from protection from hunting are considered in this paper to be valid criteria for evaluating the refuge in pheasant management. Other results of management, such as protection from predators, reduced winter losses, improved nesting success, or better survival of young birds, are considered to be attainable to an extent as great in management areas open to hunting as on wildlife refuges.

Thus, in states where hen pheasants are not legal game, the pheasant refuge, *per se*, can conceivably have an influence (1) in preventing the overshooting of cocks so as to maintain a sex ratio favorable for reproduction, (2) in reducing the illegal kill of hens by protecting that part of the population taking shelter within the refuge, and (3) in bringing about concentrations of pheasants on the refuge during the hunting season.

Two questions seem pertinent to the evaluation of refuges regarding their supposed function in preventing overshooting of cocks: (1) How many cocks will be killed under unrestricted hunting pressure in a normal open season? and (2) How many cocks can be spared from the pheasant population without hampering production of fertile eggs?

HARVEST OF COCKS

The first question has been partially answered, for Michigan conditions, by studies at the Prairie Farm in Saginaw County and at the Rose Lake Wildlife Experiment Station near Lansing. Burroughs (1939), and Burroughs and Dayton (1941), reporting on the results of hunting season checks at the Prairie Farm from 1937 to 1939, where practi-

cally complete bag checks were made for each of the 3 years, found hunting pressures to range from about 100 to more than 250 gun-hours per hundred acres, and the kill of cocks to vary from 7.3 in 1937 to 15.8 for the same land unit in 1939. The kill increased with hunting pressure, but the rate of increase fell off above 200 gun-hours per hundred acres.

Actually, it appeared that the increased kill in 1939 was the result of more pheasants in the field rather than more hunters. At the beginning of the season in 1939, hunters reported seeing more cocks per gun-hour than they had the previous year (1.25 as compared to 1.06 in 1938), yet toward the end of the season each year, it was evident that about the same density of cocks remained. In 1938 after 92 per cent of the season's kill was accounted for, hunters reported flushing .35 cocks per gun-hour, and in 1939 after 90 per cent of the kill was reported, the number of cocks seen per gun-hour was .36 (computed from authors' data).

Thus, an increase of approximately 50 per cent in hunting pressure from 1938 to 1939, with a larger population of pheasants, resulted in about a 6 per cent greater kill, but left about the same residual cock population.

Allen (1942a), reporting on both Prairie Farm and Rose Lake studies, found results on the two areas to be similar. He postulated that a "point of diminishing returns" was reached at a certain level of hunting pressure, beyond which more hunters added little to the kill. Under conditions at Rose Lake and the Prairie Farm it appeared impossible, with the highest hunting pressures likely to be experienced, to reduce the cock population to a critical level in a 22-day open season. In 1941, for example, a pressure of about 245 gun-hours per hundred acres resulted in a kill of 17 cocks per hundred acres with an insignificant kill of hens, but left a sex ratio of one cock to 3 hens.

There are relatively few places within the pheasant range where the proportion of cocks killed under a measured hunting pressure can be investigated adequately. In almost every instance reported there are unknowns which might affect the entire computation. Furthermore, in many places allowance must be made for a post-season influx of cocks from less heavily hunted areas. This factor was not operative in results reported for the Prairie Farm, since the residual population was estimated from cocks seen while hunting was still going on, but it must be taken into account in places where the effect of the hunting season is calculated from post-season surveys.

Stokes (1948) was able to eliminate the possibility of birds leaving or entering the area, since he worked with an island population. Although the harvest of cocks was made by means of intensive hunting over a 2-day season, results on Pelee Island in 1947 substantiated the Rose Lake findings. About 89 per cent of the cock population was taken in the 2-day hunt, but almost all the kill occurred before noon of the second day. Hunting during the second afternoon was largely unrewarded, and it appeared to observers that nearly all cocks had been shot. Post-season surveys, however, indicated that there was a remnant cock population of about 6 per hundred acres.

Clarke (1947) reported on the Pelee

Island pheasant kill for 1946, when, with a slightly smaller population of cocks than reported by Stokes for the following year, the percentage killed was almost the same (87.7) and the remnant slightly more than 6 cocks per hundred acres.

Randall (1940) reported a kill of 266 cocks and estimated a crippling loss of 133, from a flock of 950 pheasants on a Pennsylvania area. He did not compute the sex ratio at the beginning of the hunting season, but if this was similar to the ratio for the following fall there must have been fewer cocks than hens. If the pre-season cock population is assumed to be no more than 450 birds, the estimated kill and crippling loss would have been around 90 per cent. With this kill, the spring sex ratio was about 7 hens to one cock.

Ferrel, et al., (1949) computed the cock kill on two areas in California in 1947 and 1948. On one, the Sartain Ranch, hunting pressure increased from about 120 gun-hours per hundred acres in 1947 to almost 300 in 1948. Although the hunting season kill increased over 215 per cent in 1948, this was evidently the result of a striking increase in the bird population. It was estimated that 85.5 per cent of the cocks were killed in 1947, and 83.5 per cent in 1948. With a considerably lower pressure on the McManus Ranch in 1948 (about 190 gun-hours per hundred acres) the proportion of cocks killed was about the same as on the Sartain Ranch (86.1 per cent). The previous year, with a hunting pressure evidently somewhat lower, the cock kill on the McManus Ranch was computed to be 73.3 per cent of the pre-season population.

In the above discussion it is not meant to imply that there is a constant relationship between any given hunting pressure and the percentage of cocks that will be harvested. As a matter of fact, the evidence points to the conclusion that it is the remnant rather than the harvest that tends to remain constant. The harvest varies with the supply of cocks, but the number of cocks remaining after the hunting season tends to be a characteristic of the habitat.

Allen (1947) recognized this principle, when he suggested the concept of a "carrying capacity for cock pheasants in the face of heavy hunting." In studies at Rose Lake and the Prairie Farm he had noted that the respective post-season populations were about the same each year regardless of the number of cocks at the outset of the hunting season. At the Prairie Farm, populations were usually larger than at Rose Lake. As a result there was a larger surplus to be harvested, and a larger proportion of the cocks were taken. This resulted in more divergent sex ratios each year at the Prairie Farm than at Rose Lake.

It will be remembered that in the instance cited earlier for Pelee Island, it was relatively easy to harvest about 90 per cent of the cocks in a 2-day season, but when the remnant approached 6 cocks per hundred acres (about the level at which hunting begins in many poorly stocked areas) hunters found it very difficult to hunt out additional cocks. Undoubtedly, intensive hunting would have been required to harvest half of the remaining cocks.

The kill of cocks is, of course, not determined solely by the number of birds. Some habitats offer better escape cover than others and the experience of the birds may play a part. For example the

remaining 6 cocks per hundred acres on Pelee Island had been subjected to heavy shooting and would be more resistant to further hunting than an unshot population of the same size. Nevertheless the proportion of cocks that will be killed under heavy pressure is very likely to be directly correlated with the density of the population at the beginning of the hunting season.

A second self-regulatory factor, tending to limit the take of cocks in poorly stocked coverts, is the tendency for hunters to select favorable areas for hunting. Gower (1942) showed hunting pressure in Michigan to be directly correlated with hunting quality. For example, two counties in the heavily stocked "Thumb" area in 1941 had hunting pressures in excess of 20,000 hunters each, as opposed to four counties in western Michigan with fewer than 5,000 hunters each. The average kill per hunter was surprisingly similar, despite large differences in the total kill for these two parts of the State.

The results of self-regulatory factors are well illustrated by figures given by Buss (1946), although he did not use them in this connection. In the six most productive pheasant counties of south central Wisconsin between Green and Winnebago Counties, with a kill of more than 40,000 each in 1942, the average observed winter ratio of cocks to hens was 1:8.99. In the next most productive counties (20,000 to 40,000) this ratio was 1:3.85. In the third group of counties (5,000 to 20,000) it was 1:3.23, while in the least productive counties (1,000 to 5,000) the ratio was 1:2.73. Here it is clear that the highest proportion of cocks had been harvested in the best habitat.

Results of studies cited above appear to substantiate the principles (1) that hunting pressure is to a large degree self-regulatory, tending to be greatest in areas of highest pheasant density, (2) that the proportion of cocks killed under hunting pressures adequate for harvesting the surplus cock population varies directly with pheasant density, and (3) that hunting pressures up to 300 gun-hours per hundred acres will not normally result in a harvest of more than 75 to 90 per cent of the cocks nor, when hens are protected, in sex ratios more divergent than one cock to 8 or 9 hens.

SEX RATIOS AND FERTILITY

There has been a generally accepted rule of thumb among game farm managers that one cock to 5 or 6 hens is a satisfactory ratio, although Twining, et al., (1948) reported a conversation with an English game keeper who considered one cock to 13 hens to be optimum. Some biologists, to the contrary, have assumed that since approximately equal numbers of hens and cocks would occur in an unshot population, the optimum ratio should be one to one.

There is now convincing evidence that rather widely unbalanced sex ratios have no effect on fertility of pheasant eggs in the field. Although an extreme condition of unbalance which would result in low fertility of eggs could conceivably arise, no place has as yet been found where this condition appeared to be approached. Hence no test has been made.

Nelson (1950) reported on sex ratios and egg fertility on four South Dakota areas, in none of which was the sex ratio widely unbalanced. The lowest fertility found (87 per cent) was in the Goose Lake and Mobridge areas, where there

were 100 and 115 cocks per 100 hens, respectively. The highest fertility (97 per cent) was found in the Mitchell area, with a sex ratio of 50 cocks per 100 hens.

Baskett (1941) investigated 27 nests in Iowa, where the spring sex ratio was one cock to 2.4 hens, and found the fertility to be 83.6 per cent. This, as he pointed out, was in contrast to the findings of Randall (*op. cit.*) in which 94.1 per cent of the eggs were fertile, with a spring sex ratio of one cock to 6 hens.

Shick (1947) separated hens from cocks after one mating to learn the length of time fertile eggs would be produced. He found that the hens produced fertile eggs for an average of 22 days after one mating, with an average fertility of 77 per cent. He concluded that since hens do not all begin mating at the same time, one cock could easily service 10 or 12 hens.

Twining, et al., (1948) found that one servicing by a cock was sufficient for production of fertile eggs for about 21 days. They also found that one cock to 50 hens under penned conditions produced "normal" fertility (86.7 per cent). They were unable to test abnormal ratios in the field, because no place could be found where the ratio of hens to cocks was high enough to give a significant test. Field ratios varied from 59 cocks per hundred to 27 cocks per hundred hens. Their conclusions were that legal hunting has little effect on field fertility of pheasants in their Sacramento Valley habitat.

Undoubtedly, unrestricted shooting of cocks throughout the year could result in their virtual elimination so as to cut down reproduction. Nevertheless, the evidence strongly suggests that natural factors in addition to legal protection operate to maintain an adequate number of cocks throughout the pheasant range for maximum production of fertile eggs.

HEN KILL

The extent of illegal kill of hens in states where they are afforded legal protection is a moot question. Leedy and Hicks (1945) interviewed hunters and farmers in Ohio as to the number of hens seen shot or found dead in the field. The results of this survey indicated a high illegal kill of hens, considerably higher than shown by most subsequent investigations. They estimated that the Ohio hen kill might be 40 per cent as high as the legal cock kill. Elsewhere, Leedy (1938) quotes Hicks as estimating a kill of 66 cocks from a population of 200 pheasants per square mile in Wood County, Ohio. This would indicate a kill of some 70 per cent of the cocks and 28 per cent of the hens. Randall (*op. cit.*) thought the hen kill from a population of 950 pheasants on the Pennsylvania area studied by him was 35, a kill of about 7 per cent of the hens. Allen (1942b) found the hen kill at Rose Lake, where hunting was closely supervised, to be negligible. Ferrel, et al., (*op. cit.*) estimated the illegal hen kill to be 5 per cent of the legal cock kill on the two California areas studies.

Undoubtedly the hen kill varies from place to place, and probably from year to year. Many intangibles are involved, such as local sentiment, source of hunters, and abundance of legal pheasants. There were rumors in pheasant concentration areas in Michigan during the early 1940's that local farmers urged hunters to kill hens in the interest of

population control. Apparently this feeling, if it actually existed, swung around to one favoring protection during the low years of the middle 1940's. Hunting experience probably has an effect, at least, on accidental hen kills, but the extent of deliberate hen killing and the factors responsible for it are difficult problems to subject to scientific analysis.

Educational campaigns designed to "save the hen" may constitute the most effective pheasant management possible on a statewide scale, but again the technician finds it difficult to set up the controls necessary to make a valid test of results.

From what evidence is available it appears that an illegal kill of 20 per cent of the hen population would be well above average. This kill, and the possibility of reducing it, sets the limitations for benefits to be derived by hens from a refuge system.

Fundamentally pheasant management must be judged by birds in the bag rather than by surpluses in the field. A distinction can be drawn between a useful population, which produces its normal complement of game, and a nonproductive population which occupies vital space and may commit crop damage, yet provides no game for the hunter.

A fall population of 25 pheasants per hundred acres in a good breeding year should have almost as many cocks as hens. Shot heavily, this population should produce about 10 cocks per hundred acres or 64 per square mile, with no loss of productive capacity. A concentration of 35 pheasants per hundred acres, which is heavy enough to create damage problems for the farmer, shot to the extent of only 60 per cent of its cocks would produce no more game than the smaller population. Thus, a system of protection for hens that, at the same time, reduces the kill of cocks may result in a lower useful population from the game manager's point of view, while giving the superficial appearance of successful management.

For this reason, the closing of areas to save hens should be tempered by the need for harvesting cocks in the population. Any refuge system that would provide shelter for a significant proportion of the hens over a large area might be questioned on these grounds.

Since the most ambitious refuge programs seldom provide for more than 1 or 2 per cent of the land in refuge, and many such areas do not result in any heavy concentration of pheasants, only a small percentage of pheasants on a statewide basis will be affected by the program. For example, if 10 per cent of the pheasants of a state were to be on refuges for the entire hunting season, and thus receive the maximum possible protection, and if the illegal hen kill off the refuges be estimated at 20 per cent of the population, then the net saving of hens that could be credited to the refuge system would be 10 per cent of 20 per cent, or 2 per cent of the state's hen population.

If, under the same conditions, the legal kill of cocks be 70 per cent, then the refuge system would result in reducing the legal kill by 10 per cent of 70 per cent, or 7 per cent. Since these surplus cocks would be unnecessary for the production of the next year's crop they can be considered as "drones", competing for living space and food, and resulting in a net loss of a harvestable resource.

As an alternative, if one hunter in

fifty who might otherwise kill a hen pheasant could be deterred by means of an educational campaign, then even this slight response would result in as great a saving of hens as a very successful refuge program. Furthermore, this result could be accomplished without interfering with the legal kill of cocks, a sound goal in pheasant management.

CONCENTRATIONS ON REFUGES

The concentrating of pheasants that sometimes occurs on a refuge may be either good or bad. If the refuge constitutes superior winter habitat, results may be beneficial. In general, however, it may be more desirable to encourage dispersal of birds into all suitable winter coverts rather than to concentrate them where winter losses may be accentuated by crowded conditions. Nevertheless, it is this concentration of pheasants on favorable refuges well stocked with food and cover in heavily hunted areas that has given rise to much popular support for the refuge in pheasant management.

In this discussion it has been assumed that the pheasant refuge would function; that it would serve as a point of concentration for pheasants during the hunting season and thus would protect at least a small part of the population from the hunter. Actually, it has been observed that a large number of refuges in marginal pheasant range do not operate even to this extent.

The State of Michigan has had experience with "state wildlife sanctuaries" over a number of years. These areas are not state-owned, but are dedicated by the State Department of Conservation upon application by landowners. They are posted with state signs, however, and even the owner must obtain written permission from the Department of Conservation before he is allowed to carry firearms on the sanctuary. In all instances an inspection is made by the district game manager to learn whether wildlife habitat on the area is suitable, and the majority of applications are rejected on grounds that the habitat is not superior to that of surrounding farms.

It has been noted that these wildlife sanctuaries, with few exceptions, support no more pheasants than surrounding farms open to hunting. In a few instances, in good pheasant range where food and cover conditions on the sanctuaries were superior, and where there was heavy hunting pressure on surrounding lands, fairly large concentrations built up during open hunting seasons. In sparsely stocked areas, however, where hunting was not excessive, there was seldom any noticeable increase of pheasants on sanctuaries, even during the open season.

One high concentration on a sanctuary was at the Todd Farm, in Allegan County. On this sanctuary, with an abundance of food and natural cover, and under tenant farming where corn and small grains were interspersed with hay and truck crops, an unusually high population of birds developed during favorable years.

In common with most successful refuges, there was a high proportion of cocks in the winter population, which undoubtedly accentuated the impression of a high population. Unfortunately, no adequate studies were made on this area to give population figures for comparison with lands open to hunting. It is known, however, that pheasants on the Todd Farm followed the same downward

trend as those in the rest of the State in the middle 1940's, and that they were considered scarce in 1947.

Whether the population of the Todd Farm exceeded that of the Prairie Farm, where pheasants were heavily hunted, is not known. Undoubtedly there were more cocks, but the hens (which determine the production potential of the population) were probably no more abundant than on the open area. Certainly, the useful population, as measured by recreation afforded and game in the bag, was much greater on the Prairie Farm.

Black (1941) describes the disappointment of hunters on the Waterloo area, in Michigan, when it was opened to hunting after having been closed for 6 years. Although there had been a rising population of pheasants over most of the State during this period, pheasants on the Waterloo were evidently at a lower ebb than when the area was first closed. It was not implied that closing the area to hunting had caused the reduction in numbers, but rather that protection had in no way made up for deficiencies in habitat.

A fertile field for research is the relationship between spring breeding populations and the production of young birds. The few bits of available evidence suggest that fall populations of birds are determined less by the number of breeders than by environmental factors. If this is true, then any assumed benefits from pheasant sanctuaries would be subject to further question.

For example, Mosby and Overton (1950) found quail populations on a study area in Virginia to be fairly uniform each fall of the 6 years studied, despite considerable fluctuation in the spring breeders. They felt that a certain minimum breeding population, well below that existing during their study, would suffice to give the maximum production of quail for the area as determined by natural conditions.

Green (1948) found a similar situation for pheasants in Iowa, where about the same population density was reached each fall for 3 years, although spring breeding populations differed considerably each year.

Just as environmental factors may in some years compensate for differences in breeding stock so as to maintain a level population over a space of several years, they may at times operate to give widely divergent fall populations in years in which the spring breeding stock is similar. Kimball (1948) pointed out that the major decline in pheasant populations in the middle 1940's in South Dakota was not associated with low populations of breeders so much as with failure of the hens to produce and bring young through the summer.

It has been said of the refuge that at least it can do no harm. This may be true, except as it may in some instances contribute to winter mortality, but it may lead indirectly to unnecessary and unprofitable management.

Pheasant production is determined fundamentally by carrying capacity of the entire range, as modified annually by climatic and other variables. The goal of pheasant management, as in other game species, is to increase carrying capacity to the maximum within natural and economic limitations. Concentration of birds or of environmental improvements on small units of the range cannot be expected to compensate for deficiencies of habitat outside the

management units. Probably the greatest harm done by the refuge system is the distraction of effort from lines of management more promising of success.

Regulations should be designed to accomplish a full harvest of surplus birds. In a few highly productive areas, this will include a part of the hen population. In most parts of the pheasant range, however, it is essential to give legal protection to hens while encouraging full utilization of cocks. Any refuge system adequate for conserving a significant part of the hen population would defeat its purpose by preventing an adequate harvest of cocks.

SUMMARY

1. Cock pheasants in favorable habitats have demonstrated ability to withstand hunting pressures up to 300 gun-hours per hundred acres and maintain a satisfactory remnant for breeding purposes.

2. Sex ratios of 10 or more hens per cock are adequate for the production of fertile eggs, and there is evidence that much wider ratios could be tolerated without loss of fertility.

3. Sex ratios divergent enough to reduce egg fertility have not been reported, even in areas of high hunter concentration.

4. Since other pheasant management goals can be attained without protection from hunting, the refuge, *per se*, must be judged solely on results of a reduced hunting season kill.

5. Even with unusually effective refuges, the reduction in statewide hen kill attributable to refuges is not likely to amount to more than 2 per cent of the hen population. This would be accompanied by a larger reduction in harvest of cocks.

6. Since the usable pheasant population is measured by the harvest, any unnecessary reduction in cock kill must be considered a waste of the game crop and contrary to good management.

7. Legal protection and educational programs designed to save hen pheasants are more selective and probably more effective than refuges in pheasant management.

8. Pheasant populations are products of habitat. Improvement of the entire range within economic limitations and the full utilization of annual population surpluses wherever practicable appear to be reasonable goals of management.

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IMPROVING CONDITIONS FOR FISH IN BROWN-WATER BOG LAKES BY ALKALIZATION *

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The object of this study was to discover methods for increasing the productivity of small kettle lakes which have characteristically brown-colored water. Owing to the light-absorbing action of the pigmented solutes and suspensoids of the water, the sun's energy cannot express its optimum effect on the basic fish food supply—plants. Hence, any treatment which would free the water of its brown color and still not be toxic to fish would enhance productivity, since such a treatment would increase the depth of light penetration and therefore the volume of the food-producing (trophogenic) zone. Increased fish production should follow.

James and Birge (1938) and Sauberer and Ruttner (1941) demonstrated that the colored materials of lake water reduced the depth to which the light penetrated. Their results showed also that it was absorbed selectively, especially those wave lengths which were most effective in photosynthesis.

It has been generally observed that seepage water from limed and undrained peat marshes now in use for agriculture is clear, while that from unlimed ones is tea-colored. This observation suggested to us (Hasler and Einsele, 1948) that lime treatment of acid, brown-water, lakes might likewise clear up the water and therefore increase the depth of the trophogenic zone. Theoretically, if lime were added to lakes the calcium would combine with the humic colloids forming a humate which would flocculate and fall to the bottom. Moreover, alkalization of the water would produce a better medium for bacteria so that suspended organic colloids would be, in part, degraded.

It is well known that acid conditions are unfavorable to decomposition by micro-organisms. We therefore postulated that alkalization through lime treatment might also augment the activities of organic decomposition at the bottom as has been observed in European fish ponds and reviewed by Neess (1948). This action would, theoretically, reduce the rate of accumulation of debris and therefore retard the aging process of the lake and give it additional years of life.

Procedure and Results:

In 1947 a treatment study was initiated on a lake in Langlade County but was given up because of a number of extraneous reasons. However, in 1948 owing to the generous cooperation of Mr. Ben S. McGiveran, Milwaukee, and the International Minerals and Chemical Corporation, Chicago, the project was reestablished on two McGiveran lakes which are in Chippewa County, Wisconsin (T. 32 N.R. 9W).

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They are small kettle lakes with an average depth of 5–6 m. and lie in terminal moraine.

HYDROGRAPHIC DATA IN ENGLISH AND METRIC UNITS

Lake	Turk		Cather	
	English	*Metric*	*English*	*Metric*
Area	8.8 a.	3.5 ha.	8.4 a.	3.4 ha.
Av. Depth	11.5 ft.	3.5 m.	16.4 ft.	5.0 m.
Max. Depth	19.7 ft.	6.0 m.	32.8 ft.	10.0 m.

Their catchment basins are small, and the soils are poorly drained clay underlayed by hard pan. These edaphic conditions explain the acidity and the paucity of solutes, especially P, N, and Ca (Table 1). The average July air temperature is 68° F.; January, 11.3° F.

Observations on limnological features, including the fishery, were made two years (1948 and 1949) prior to treatment. After removal of the resident fish population by application of derris root, rainbow and brown trout were stocked; a more complete record of the fishery will be published after an examination of the results in the second year of post-treatment.

To alkalize the water before the ice was out in April 1950, finely ground lime * (calcium and magnesium hydroxide) was used. The chemical was scattered on the ice, but in subsequent additions it was poured over the bow or stern of a rowboat so that the turbulence from an outboard motor churned the powder into the water. Later, a small amount of $CaCO_3$ was spread near shore. A record of the amounts added and the before and after levels of methyl orange alkalinity, pH, and transparency are given in Table 2. Initial application of lime should be done during the spring or fall circulation (turnover) periods to obtain maximum mixing and hold to a minimum the risk of getting localized lethal concentrations.

By July the water had cleared remarkably in Cather Lake as can be seen from the disk reading in Fig. 1. Because a light meter was not available for pretreatment records a nearby lake, Skow Lake, was chosen for comparison. Limnological and edaphic conditions on this lake are similar to those of Cather and, in addition, transparency readings

* limate = CaO:48.3; MgO = 33.2; H_2O = 16.8. Mfg. by Western Lime and Chemical Company, Milwaukee, Wisconsin.

TABLE 1.—JULY 18, 1949

	Cather		Turk	
	18 July '49	9 Oct. '50	18 July '49	9 Oct. '50
Sol. P.	—	0.006	—	0.0
Tot. P.	0.116	0.16	0.120	0.551
SiO_2	0.266	—	0.320	—
Fe	0.112	0.035	0.031	0.05
SO_4	1.83	1.2	2.25	1.4
Mn	0.150	0.076	0.126	0.06
NO_3—N	0.100	0.09	0.072	0.064
NO_2—N	0.0026	0.0	0.0016	0.0
NH_3—N	0.094	0.051	0.166	0.047
T. O. N.	0.673	0.474	0.266	0.551

Chemical Analysis by courtesy of Prof. G. A. Rohlich, Division of Sanitary Engineering, University of Wisconsin.

TABLE 2.—ADDITION OF LIME TO CATHER LAKE AND TURK LAKE, WISCONSIN, AND SUBSEQUENT CHANGES IN ALKALINITY, pH AND TRANSPARENCY

Date	Cather				Turk			
	Lime added in lbs.	pH	Alk. in mg/1 $CaCO_3$	Disk	Lime added in lbs.	pH	Alk. in mg/1 $CaCO_3$	Disk
10 III	1700	5.6	3.0	ice	—	—	—	—
19 V	—	6.3(a)	13.0	2.0	—	—	—	—
19 V	1100	8.4(b)	13.0	—	—	—	—	—
15 VI	—	7.2	—	4.3	—	—	—	3.5
19 VI	—	—	—	4.4	—	5.4	3.0	3.5
28 VI	450	7.1	17.0	5.0	—	—	—	4.0
4 VII	—	—	—	5.2	800	—	3.0	3.8
21 VII	—	—	—	5.3	200	7.2	9.0	4.5
25 VII					250	6.9	—	—
12 VIII	—(c)	7.1	16.0	>5.0	(c)	6.8	—	4.0
24 VIII	—	7.5	19.0	5.7	400	6.8	11.0(d)	4.0
30 VIII	—	—	—	—	300	7.0	—	—
1–2 IX	—	7.3	16.0	5.7	400	6.9	11.0	4.5
6 X	—	7.1	15.0	5.1	1000	6.9	13.0	3.3
6 X	1000	8.7(b)	—	—				

(a) Reading before introducing lime.
(b) Reading after introducing lime.
(c) 320 lbs. of $CaCO_3$ introduced.
(d) 18 August 1950.

were identical in 1949. Fig. 2 shows the curves of the photocell readings. These lend more precision to the Secchi disk readings and demonstrate that the light penetration of the treated lake is double that of the untreated.

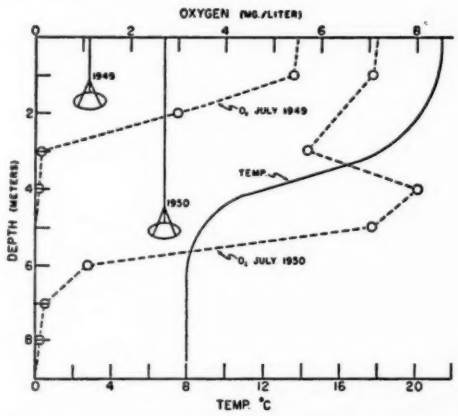

FIG. 1. Transparency and oxygen in Cather Lake before and after treatment with lime.

Throughout the summer the pH of the bottom water was always less than neutrality in Cather, varying from pH 6.3 to 6.5, while the methyl orange alkalinity was always greater at the bottom than at the surface; 2 mg./liter more in July and as much as 15 mg./liter in October. A comparison of the before and after alkalinity and pH readings is given below:

Depth Meters	Alkalinity as mg./1. $CaCO_3$		pH	
	1949	1950	1949	1950
0	5.0	20.0	5.4	7.1
9	4.8	22.0	5.2	6.4

An initial precautionary estimate can be made of the amount of lime necessary to change the pH of a water from acid to alkaline if the pH and methyl orange alkalinity are known in advance but it is advised that samples of water be taken from a lake to determine, by experiment, that quantity of lime which

is necessary to attain a desired pH under laboratory conditions. If then the total volume is known computations can be made for additions of lime in conservative amounts so that damage to aquatic organisms can be avoided.

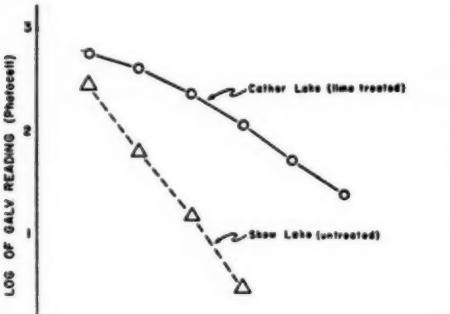

FIG. 2. Comparison of Light Penetration on two bog lakes: Cather Lake, lime treated; Skow Lake, untreated. (Galv. reading in milliamps).

For Cather Lake with pH 5.4 and M.O.A. 5.0 p.p.m. a treatment of 0.77 lbs./1000 cu. ft. (66 kg./1000 cu.m.) raised the pH to 7.2–7.4.

Bottom muds will neutralize the lime to some extent; consequently, additions must be made to compensate. Moreover, the photosynthetic action will remove CO_2 from the bicarbonate leaving carbonate which will settle out. We believe, therefore, that continuous additions must be made to maintain neutrality. Just what the magnitude of these factors are we do not know at this stage of management. In this case it was considerable; while 1,095 lbs. would have been necessary to get the desired pH change of Turk Lake water in a glass container, in actual practice 3500 lbs. were necessary.

In contrast to Cather Lake, alkalization of Turk Lake was done gradually by small additions periodically throughout the summer (Table 2). This method did not bring the water to neutrality by the end of the summer nor did the transparency improve. Rapid alkalization where neutrality was accomplished at the start of the season, as was done on Cather Lake, appears to give the most satisfactory result. Chemical analysis before and after alkalization did not reveal any striking differences in the essential fertilizing nutrients (Table 1).

Significance:

Throughout the glacial lake regions, where the catchment basins are low in carbonate, bog lakes and other lakes with acid tea-colored water are common. Without exception their production of fish is low compared with lakes in nutrient rich areas. In many instances the fishes in these lakes are dwarfed making them of little use to the sport fishery but the causal factors are not well understood. Three possibilities of some significance are:

1. Low penetration of sunlight owing to the brown pigments and their selective light absorbing action (James and Birge, l. c.), resulting in a restriction of the production of algae to the upper waters.

2. Acid water, low in nutrients.

3. A very low reservoir of available CO_2 (Ohle, 1937, and Juday et al., 1935), which furnishes a basic compound for the most fundamental energy process, photosynthesis.

A method for improving habitat conditions in these unproductive lakes is highly desirable. Lime treatment will increase light penetration and allow for capture of more of the sun's energy.

Such an improved lake, if cleared of its resident dwarfed pan fishes, would have conditions favorable for trout production since sufficient O_2 is then present in the cooler layers, whereas before there was insufficient O_2 below the epilimnion. Furthermore, a generally increased volume of productive water might also make a treated lake more fertile also for shore fishes. For those who would make ultimate use of increasing fish production bass could be used for creating a "two-story" lake; bass in the littoral, epilimnetic zone and trout in the cooler waters of the thermocline. This scheme has been used where trout were introduced into bass lakes, provided that sufficient oxygen persisted in the deep cooler strata.

Many bog and other shallow dark-water lakes in northern Wisconsin are subject to frequent winter-kill owing to a rapid uptake of the oxygen reservoir by decomposition and to poor light-transmitting qualities. Clearing up the water with lime would encourage greater light penetration. Also because of the removal of organic suspensoids the O_2 reservoir would not be depleted as fast and thus would hold intermittent winter-kills to a minimum.

These results make it appear that alkalization may prove to be a valuable, but cheap, management tool, costing, in this instance, $0.60 per acre-foot for the first year and probably a fraction of this in subsequent years. Also, alkalization of the water tends to mobilize nutrients bound up in acid undecomposed lake soils. Moreover, the lime treatment raises the bicarbonate content and hence makes available an abundant source of CO_2, an essential nutrient.

Furthermore, it is our belief that extinction of a bog lake under acid conditions is more rapid than extinction of an alkaline lake of similar size and in a similar climate. The rapid encroachment of the bog mat (Dachnowski-Stokes, 1933) in addition to the slow rate of decomposition under acid conditions, augments the process of encroachment of the shore on the main body of the lake. This rate is probably faster under acid than under alkaline conditions. It is quite likely therefore that liming of a bog lake may delay this ("Verlandung") process and lengthen its life span.

Bog and tea-colored kettle lakes in their natural state have a definite beauty which should be retained, in some measure at least, and not exchanged for better fishing. Consequently, appraisal of esthetic values should be made before wholesale treatment is undertaken.

Finally, in addition to increasing lake productivity for the sport fishery and marsh management this method could be given serious consideration for increasing protein supplies in times of emergency. When one is considering matters of national defense every food resource must be taken into account as well as the means for increasing it. Contamination of coastal fisheries and Great Lakes fisheries is a possibility. Any method which might increase protein productivity of the smaller inland lakes may eventually have survival value. Growing concern for adequate protein diets is being posed with an advancing human birth rate. More research along this line should be forthcoming from our fishery biology laboratories.

SUMMARY

Alkalization of an acid brown water Wisconsin lake with lime resulted in a two-fold increase in transparency of the water in addition to an increase in oxygen levels at cooler strata.

The resulting clearer waters makes possible the capture of more energy, therefore increasing general lake productivity. The production of fish can thus be raised by increasing the volume of the trophogenic zone by a relatively inexpensive procedure.

Specifications and method of application of the chemical are described.

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COMPOSITION OF SOME PLANTS EATEN BY DEER IN THE BLACK HILLS OF SOUTH DAKOTA [1,2]

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[2] The authors wish to acknowledge the assistance of Dave Harris, State Game Warden, Deadwood, South Dakota; and Ralph R. Hill, Biologist, Wildlife Management Division, U.S. Forest Service, Denver, Colorado. These men had an important part in planning this project in 1943.

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The white-tailed deer (*Odocoileus virginianus macrourus*) and the mule deer (*O. hemionus*) of the Black Hills of South Dakota are largely dependent upon browse plants for food as shown by 263 stomach analyses reported by Hill and Harris (1943). The browse plants are especially predominant in the diet during the winter months. For the critical period, January to April in the years 1940 to 1944, browse plants made up 70.9 per cent of the deer diet by volume; forbs were 12.1 per cent, grains 4.9 per cent, grass 7.2 per cent and miscellaneous items 4.9 per cent. Ten species of browse plants made up practi-

cally all of the 70.9 per cent of the diet; and among these, bearberry (*Arctostaphylos uva-ursi*) and Oregon grape (*Odostemon repens*) made up 36.5 per cent. For comparative purposes the more common shrubby plants of the Black Hills are listed below in their relative importance to deer as food.

TABLE 1.—COMMON BLACK HILLS BROWSE PLANTS LISTED ACCORDING TO THEIR RELATIVE IMPORTANCE AS FOOD FOR DEER IN WINTER *

HIGH	MEDIUM	LOW
Bearberry	Serviceberry	Willow
Oregon grape	Chokecherry	Twinflower
Pine	Buckbrush	Red willow
Ground juniper	Bur oak	Sumac
	Snowbrush	Spiraea
	Rose	Russet buffaloberry
		Ironwood
		Hazel
		Horizontal juniper
		Yucca
		Aspen
		Paper birch

* Several of the species listed under the LOW classification are relished by deer but are not abundant enough on the range to be important in the diet in this area.

Field studies during the five year period (1941–1945) by members of the South Dakota Department of Game, Fish and Parks and the Forest Service in the northern Black Hills have shown that the deer were selecting these few highly palatable plants and heavily overbrowsing them in the presence of many other species which went untouched. Many cases of death in winter due to malnutrition have been recorded. Because of this situation it was believed important to determine in what way, and to what extent, the more common deer foods might be deficient in the basic nutrients. Also it was hoped that chemical analyses might reveal why plants such as russet buffaloberry, hazel and ironwood, though abundant, were uneaten. A complete picture of the food value of a plant is not given by chemical analysis alone. More information can be obtained only as a result of the use of the plant by the animal. Chemical analysis is, however, one method used in making a survey of this nature and enables one to make a comparison of the different plant foods.

In October, 1943, eleven important species of plants were selected for chemical analyses. The eleven species selected were: aspen (*Populus tremuloides*), bearberry (*Arctostaphylos uva-ursi*), serviceberry (*Amelanchier spicata*), ground juniper (*Juniperus communis*), rose (*Rosa spinosissima*), snowbrush (*Ceanothus velutinus*), Oregon grape (*Odostemon repens*), beaked hazel (*Corylus rostrata*), blue grass (*Poa sp.*), buffaloberry (*Shepherdia canadensis*), and paper birch (*Betula papyrifera*). Based on observations of the feeding habits of deer and many stomach analyses, the first seven species were listed as being palatable and the last four as being nonpalatable to deer. Samples of these species were taken on Aztec Hill, Spearfish District, Lawrence County, South Dakota, and sent to the Experiment Station Chemistry Department for analyses. Similar samples were taken in January, April, and July, 1944. In taking the samples an effort was made to take only that portion of the plant normally eaten by deer.

The standard methods of the Association of Official Agricultural Chemists (1940) were used to make the regular feed analysis in terms of moisture, ash, crude protein, crude fat, crude fiber and nitrogen-free extract. Additional determinations of carotene, phosphorus, cal-

cium, iron, and manganese were also made. The resulting data are summarized in Table 2.

The table shows considerable differences in the chemical composition of the various plants. Distinct variations in the composition of some of the species between seasons are also evident. In general, the highest phosphorus, ash, carotene and crude protein values, as percentage of dry weight, for each species were found in the July samples. Carotene values for both palatable and non-palatable groups showed a decline from October 1 to January 1 and then rose to the highest value in the July samples. In general these plants are low in phosphorus as compared with forages used for livestock feeding.

In 1945 analyses were made on seven species of plants which had not been included in the first group. These species were: pine, outside and inside needles (*Pinus ponderosa*), horizontal juniper

TABLE 2.—PERCENTAGE COMPOSITION OF DEER FOODS AS PICKED ON FOUR DATES
(a) October 1, 1943 (b) January 1, 1944 (c) April 1, 1944 (d) July 1, 1944

Species	Moisture	Carotene*	Ash	Crude Fat	Crude Fiber	Crude Protein	N-Free Extract	Phosphorus	Calcium	Iron†	Manganese†
Aspen	a. 42.78	8.16	2.72	8.12	14.69	3.63	28.06	.076	.78	80.76	21.35
Aspen	b. 43.53	7.94	2.45	6.74	13.68	3.39	30.21	.086	.89	79.43	25.21
Aspen	c. 42.63	22.66	2.31	8.20	13.90	3.72	29.25	.10	.74	44.15	22.32
Aspen	d. 55.75	6.47	2.09	5.95	11.63	3.14	21.43	.11	.48	76.37	11.30
Aspen††	d. 61.03	98.18	2.02	2.57	6.15	5.37	22.87	.08	.40	40.67	17.54
Bearberry	a. 47.54	18.67	1.93	5.97	9.00	2.70	32.86	.064	.39	270.75	12.38
Bearberry	b. 49.11	10.86	2.01	4.88	8.29	2.55	33.16	.067	.60	309.28	13.36
Bearberry	c. 36.65	31.97	2.27	8.28	9.18	2.98	40.63	.09	.52	236.51	20.91
Bearberry	d. 60.81	38.10	1.66	4.72	6.22	3.30	23.29	.08	.22	173.70	16.29
Serviceberry	a. 43.53	3.23	2.54	2.26	15.11	3.05	33.51	.075	.76	73.69	78.78
Serviceberry	b. 40.11	2.90	2.07	2.96	14.84	3.71	36.31	.092	.69	71.95	40.82
Serviceberry	c. 41.34	12.48	1.96	2.92	15.21	3.67	34.90	.11	.56	64.55	21.45
Serviceberry	d. 53.01	6.77	1.97	2.21	13.02	2.72	27.07	.07	.64	54.07	22.49
Serviceberry††	d. 62.52	28.61	2.63	1.65	6.56	5.45	21.19	.20	.41	36.49	35.63
Juniper	a. 50.27	56.63	1.41	6.07	11.28	4.22	26.75	.087	.36	94.97	43.62
Juniper	b. 43.48	16.30	1.65	7.51	15.50	3.30	28.56	.081	.85	91.02	58.82
Juniper	c. 43.81	52.08	2.00	7.16	12.70	2.85	31.49	.12	.67	92.68	80.19
Juniper	d. 66.13	57.88	1.38	4.12	9.51	3.53	15.35	.07	.25	40.49	45.98
Rose	a. 48.71	21.30	2.53	7.14	11.11	4.67	25.84	.100	.52	109.48	25.77
Rose	b. 32.72	4.73	1.93	1.85	21.60	3.84	38.06	.097	.54	108.99	39.42
Rose	c. 34.82	6.83	2.17	1.79	23.63	3.26	34.34	.11	.67	74.01	24.06
Rose	d. 69.32	38.28	1.69	1.35	4.10	5.46	18.07	.12	.25	59.48	14.89
Snowbrush	a. 48.70	35.74	1.31	5.15	7.08	6.20	31.56	.069	.33	100.14	44.15
Snowbrush	b. 41.37	30.10	1.47	4.32	8.14	6.31	38.39	.083	.61	78.22	82.87
Snowbrush	c. 49.75	11.55	1.44	2.82	8.54	5.40	32.04	.08	.42	68.42	53.10
Snowbrush	d. 65.36	72.53	1.65	1.75	4.75	6.40	20.09	.11	.25	58.45	42.87
Oregon grape	a. 51.24	42.03	1.46	1.96	15.49	4.77	25.08	.100	.24	90.06	79.29
Oregon grape	b. 49.16	8.19	1.38	2.12	16.33	4.36	26.65	.088	.26	84.24	101.13
Oregon grape	c. 47.52	27.21	1.52	2.27	15.40	4.32	28.97	.11	.28	44.76	84.99
Oregon grape	d. 62.95	66.97	1.26	1.43	9.34	5.53	19.49	.06	.17	57.74	37.74
Beaked hazel	a. 38.23	4.84	2.29	2.94	16.82	4.09	35.63	.070	.60	87.69	99.14
Beaked hazel	b. 22.91	4.11	2.29	2.58	22.45	4.72	45.05	.087	.67	86.46	125.86
Beaked hazel	c. 34.43	16.19	2.22	2.51	17.54	4.29	39.02	.10	.70	80.73	112.27
Beaked hazel	d. 59.26	8.66	1.63	1.87	12.49	3.16	21.58	.08	.45	52.14	36.92
Beaked hazel††	d. 64.74	46.96	2.04	.85	7.21	6.16	18.99	.11	.49	52.87	49.47
Blue grass	a. 57.15	27.58	4.30	1.10	14.16	3.03	20.26	.088	.23	85.99	4.75
Blue grass§	b. 86.93	13.46	1.29	.34	4.79	.72	5.93	.021	.07	77.23	4.13
Blue grass	c. 38.27	6.39	6.76	1.60	20.30	3.26	29.82	.06	.31	530.29	39.82
Blue grass	d. 68.18	86.58	2.81	1.31	10.36	4.18	13.15	.10	.11	20.73	3.01
Buffaloberry	a. 47.69	15.99	1.19	1.67	10.88	8.13	30.44	.086	.40	172.56	12.88
Buffaloberry	b. 41.86	10.54	.88	1.47	13.19	9.55	33.05	.102	.19	179.84	16.19
Buffaloberry	c. 37.62	15.42	1.29	1.38	14.88	9.48	35.35	.13	.24	65.16	12.37
Buffaloberry	d. 64.48	20.95	.78	.91	10.01	4.76	19.06	.07	.11	49.04	7.01
Buffaloberry††	d. 73.13	111.22	1.68	1.57	4.20	5.76	13.66	.08	.17	61.19	16.02
Paper birch	a. 42.85	7.50	1.66	7.44	11.61	4.37	32.07	.094	.41	99.08	83.41
Paper birch	b. 37.90	5.01	1.66	8.09	13.91	5.63	32.81	.114	.64	95.02	85.10
Paper birch	c. 21.69	12.13	1.97	8.55	18.83	5.94	43.02	.18	.56	87.01	124.38
Paper birch	d. 69.55	5.79	1.19	1.76	8.38	2.87	16.25	.08	.27	44.62	41.98
Paper birch††	d. 66.86	63.76	1.56	1.81	5.32	5.68	18.77	.12	.29	36.99	64.18

* micrograms per gram
† parts per million
†† leaves; other data on these species at this date are for stems from which the leaves were separated
§ moisture content high because sample was very wet when clipped and weighed

TABLE 3.—PERCENTAGE COMPOSITION OF DEER FOODS AS PICKED ON FOUR DATES IN 1945
(a) January 18, (b) May 16, (c) June 27, (d) October 22

Species	Moisture	Carotene*	Ash	Crude Fat	Crude Protein	Crude Fiber	N-Free Extract	Calcium	Phosphorus	Iron†	Manganese†
Pine inside	a. 53.56	40.44	.89	4.21	3.11	13.54	24.69	.17	.067	50.96	25.43
Pine inside	b. 46.51	47.03	.97	4.87	3.48	15.07	29.10	.12	.078	51.79	6.66
Pine inside	c. 46.99	53.90	1.16	4.99	2.77	15.09	29.00	.26	.062	83.07	24.90
Pine inside	d. 57.35	65.84	1.10	3.20	2.76	14.34	21.25	.12	.075	55.69	38.25
Pine outside	d. 55.83	14.92	.86	4.36	3.12	12.05	23.78	.15	.061	50.20	9.53
Pine outside	b. 43.45	38.86	1.16	5.65	3.86	15.59	30.29	.18	.078	67.65	6.00
Pine outside	c. 53.14	22.27	.87	4.87	2.54	13.57	25.01	.17	.06	64.58	7.35
Pine outside	d. 55.21	86.11	1.10	3.91	3.13	13.61	23.04	.16	.065	53.62	11.97
Hor. juniper	a. 50.47	10.14	2.71	6.32	3.33	12.64	24.53	.83	.078	168.42	19.93
Hor. juniper	b. 47.15	21.96	2.59	5.94	3.37	12.22	28.73	1.00	.081	213.85	47.91
Hor. juniper	c. 49.89	24.96	2.48	4.92	3.62	11.38	27.71	.79	.087	169.92	21.93
Hor. juniper	d. 55.05	37.18	2.17	6.45	3.78	10.34	22.21	.72	.085	93.28	23.30
Chokecherry	a. 51.54	2.89	2.27	.84	4.74	15.13	25.48	.74	.086	75.72	65.79
Chokecherry	b. 57.14	5.37	1.90	.83	5.50	12.04	22.59	.64	.132	81.71	42.73
Chokecherry	c. 65.31	48.39	2.42	1.28	6.74	5.13	19.12	.48	.198	50.17	29.30
Chokecherry	d. 51.53	7.09	1.79	1.24	5.52	12.71	27.21	.68	.111	77.11	35.83
Oak	a. 43.82	3.28	3.38	.86	3.61	18.89	29.44	1.07	.070	125.00	109.28
Oak	b. 40.24	2.93	2.59	1.14	3.67	22.36	30.00	.84	.089	139.50	146.35
Oak	c. 67.39	55.00	1.74	.66	7.03	7.55	15.63	.23	.148	58.54	24.01
Oak	d. 47.42	10.49	1.99	.92	3.38	18.96	27.33	.56	.066	72.68	112.72
Buckbrush	a. 36.80	13.54	2.38	1.28	3.32	23.20	33.02	.36	.072	165.82	61.76
Buckbrush	b. 58.01	4.01	2.02	1.06	5.42	12.75	20.74	.26	.166	128.41	39.95
Buckbrush	c. 66.12	40.62	2.26	1.24	4.46	5.41	20.51	.21	.15	40.83	8.71
Buckbrush	d. 54.01	14.35	2.67	2.20	2.99	5.77	32.36	.54	.144	87.88	28.31
Yucca	a. 60.10	27.60	1.59	1.13	4.78	14.81	17.59	.33	.100	40.76	23.20
Yucca	b. 55.68	22.10	1.57	1.28	3.97	15.97	21.53	.43	.070	67.31	16.54
Yucca	c. 64.71	18.04	1.87	.73	3.93	14.62	14.14	.31	.117	32.82	7.84
Yucca	d. 61.42	43.48	1.49	1.24	3.56	14.67	17.62	.28	.077	48.11	13.34
Ironwood	a. 42.12	6.00	2.20	1.09	3.95	21.83	28.81	.69	.066	84.09	76.40
Ironwood	b. 43.93	6.66	2.32	1.27	4.81	20.44	27.23	.79	.119	139.49	95.94
Ironwood	c. 58.94	76.99	2.55	.82	7.15	7.49	23.05	.63	.148	109.94	56.81
Ironwood	d. 40.74	34.76	3.34	1.85	3.56	15.56	34.95	1.02	.126	160.36	143.62

* micrograms per gram
† parts per million

(*Juniperus horizontalis*), chokecherry (*Prunus melanocarpa*), bur oak (*Quercus macrocarpa*), buckbrush (*Symphoricarpos occidentalis*), yucca (*Yucca glauca*), and ironwood (*Ostrya virginiana*). Ironwood is the only non-palatable species in the above list. The data for the chemical analyses of these species are summarized in Table 3.

This table also shows differences in composition among the species and variations between sampling dates. For most of the species, the June samples show the highest values for crude protein, carotene, and phosphorus.

The January 1 samples of the plants in the first group were also analyzed for reducing and total sugars in hopes of finding some correlation between sugar content and palatability. The method used was that of Hassid (1936). The sugar contents of these plants are shown in Table 4.

TABLE 4.—SUGAR CONTENTS (PERCENT) OF DEER FOODS FOR THE JAN. 1, 1944 SAMPLING
(As picked basis)

Species	*Reducing*	*Total*
Aspen	1.62	2.36
Bearberry	3.34	5.87
Serviceberry	1.34	1.84
Juniper	2.28	4.06
Rose	2.12	3.16
Snowbrush	2.92	6.16
Oregon grape	3.00	4.48
Beaked hazel	1.92	3.44
Blue grass	.11	.16
Buffaloberry	.63	2.08
Paper birch	1.27	4.06

DISCUSSION

A comparison of the chemical composition of the palatable and non-palatable species of deer feed does not indicate why the plants should be thus classified. The average calcium, crude fat, and

nitrogen-free extract values were higher for the plants in the palatable group while the plants in the non-palatable group showed higher average phosphorus, ash and crude protein values. Swift (1948) in a study of the composition of wheat and clover, noted that deer, entirely free to choose, ate those feeds which gave them a higher per cent of crude fat, calcium, and phosphorus. Russet buffaloberry, which is abundant, has a higher crude protein content than any of the other species and yet is listed as being non-palatable. There appears to be no direct correlation between phosphorus content and palatability. Forbes *et al.* (1941) in conducting digestion experiments with deer, associated high fiber content with low nutritive value. In the second group of plants which was analyzed, ironwood listed as the only non-palatable species, is not too different in composition from several of the species in the palatable group.

The "critical period" for the deer is from January to April. Many of the chemical constituents of both palatable and non-palatable species are at the lowest values for the January 1 and the April 1 samplings. Forbes *et al.* (1941) found that winter feed was of much lower nutritive value than the late fall feed. Hellmers (1940) studied the monthly variations in chemical composition of eight species of woody-plants browsed by deer and found marked differences indicating reduction in nutritive value through the winter.

As a group, the palatable species had a higher content of both reducing and total sugars than did the non-palatable group. Sugar content might be an index for classifying plants as palatable or non-palatable for deer but in this respect we again have exceptions. Several of the non-palatable group have either more reducing or more total sugars than some of the species in the palatable group.

Nichol (1938) reports that deer appear to detect readily, and avoid, cyanide in plants. Additional chemical analyses for constituents other than those listed in the above tables might make the picture more complete as regards palatability and non-palatability.

SUMMARY

Samples of eleven species (seven palatable, four non-palatable) of plants browsed by Black Hills deer were collected at intervals of three months over a two year period (1943 and 1944) and analyzed for moisture, ash, crude protein, crude fat, crude fiber, nitrogen-free extract, carotene, phosphorus, calcium, iron, and manganese.

In a second period of sampling (1945), seven other species (six palatable, one non-palatable) were collected at four different sampling dates and analyzed chemically.

Palatability was based on observations of feeding habits of the deer and examination of stomach contents from many deer.

Differences in chemical composition of the various species and variations in the chemical composition of the same species at different sampling dates were found. The chemical analyses did not give an adequate explanation for the division of the species into palatable and non-palatable groups.

All species, whether palatable or non-palatable, did not show a great reduction in those chemical constituents, except carotene, which might in turn be

indicative of a reduction in nutritional value through the "critical period" January to April.

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ABUNDANCE AND GROWTH OF GIZZARD SHAD, DOROSOMA CEPEDIANUM (LESUEUR), IN A SMALL ILLINOIS LAKE [1]

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It is generally known among fishery workers of the central states that the gizzard shad is a fish of high biotic potential and rapid growth. Its ability to preempt the fish production in various waters is likewise known (Bennett, 1943), though not extensively documented. This ability, as well as previous assays of growth rate (e.g., Lagler and Applegate, 1941) are substantiated by data from Beaver Dam Lake, Illinois.

Beaver Dam Lake is a shallow body of water, seven miles south of Carlinville, Illinois. The maximum depth is about 8 feet and surface area, approximately 110 acres. The lake is reported to have been formed originally by beaver, some 80 years ago. In 1908 it was more permanently dammed by man; additional improvements to the holding structure were made by the State in 1947. The bottom is muddy and beds of *Potamogeton crispus* have become both extensive and dense.

Seining and poisoning operations conducted by the Illinois Department of Conservation in December, 1948, and March, 1949, respectively, provide a reliable estimate of the standing fish crop (Table 1). Gizzard shad and bluegills usurped most of the fish producing capacity of Beaver Dam Lake. Largemouth bass were apparently unable to regulate significantly the populations of these two species. Seining operations through the years appear to have been reasonably effective in the control of carp, buffalos and quillbacks, but ineffective on gizzard shad.

Materials for growth study are from 1,136 gizzard shad collected from July

[1] Contribution from the Illinois Department of Conservation and from the Department of Fisheries, University of Michigan.

TABLE 1.—FISH RECOVERED FROM BEAVER DAM LAKE, ILLINOIS, BY SEINING IN DECEMBER, 1948, AND BY POISONING IN MARCH, 1949

(Data by courtesy of Sam Parr and William Harth, Illinois Department of Conservation)

Kind of Fish*	Total Number	Total Weight (Pounds)	Pounds Per Acre	Average Weight Per Fish (Pounds)	Percentage of Total Weight
Game fish (total)	1,373	2,030	18.5	1.48	3.6
Largemouth black bass	1,373	2,030	18.5	1.48	3.6
Pan fish (total)	272,627	23,895	217.2	0.09	41.9
Bluegill	247,910	19,843	180.4	0.08	34.8
Black crappie	8,741	599	5.4	0.07	1.1
White crappie	6,528	428	3.9	0.07	0.8
Yellow bass	1,647	240	2.2	0.15	0.4
Green sunfish	923	60	0.5	0.07	0.1
Bullheads**	5,563	2,225	20.2	0.40	3.9
Channel catfish	1,315	500	4.5	0.38	0.9
Rough fish (total)	350	3,860	35.1	11.03	6.8
Carp	345	3,800	34.5	11.01	6.7
Buffalos***	5	60	0.5	12.00	0.1
Forage fish (total)	630,448	27,198	247.3	0.43	47.7
Gizzard shad	627,906	27,000	245.5	0.43	47.4
Golden shiner	2,542	198	1.8	0.08	0.3
Miscellaneous****					0.1
GRAND TOTAL	904,798	56,983	518.0	0.06	

*Fish names follow those in Special Publication No. 1 of the American Fisheries Society, 1948.
**Includes both black and yellow bullheads.
***Includes both smallmouth and bigmouth buffalos.
****Includes orangespotted sunfish, warmouth, quillback, and white sucker.

30 to September 2, 1948, and from 375 additional specimens seined on December 21, 1948. Gill nets accounted for most of the July-September fish, but a few larger individuals were taken in trammel and fyke nets. The earlier specimens are the complete sample as selected by the collection gear. The later sample was selected to bolster the numbers of young-of-the-year fish as well as fish over 11 inches in total length. Of the overall sample, scale analyses were made of 422 individuals drawn at random to represent equally, as nearly as possible, each 1/2-inch interval of the total range in size.

Sexual dimorphism did not manifest itself in the rate of growth of these fish. Growth curves, plotted separately, showed no appreciable differences in character. Data for both sexes were consequently combined to strengthen the numbers in the various size groups. This is also true for the analysis of the length-weight relationship.

Length at various ages may be determined in a variety of ways (Table 2). Our estimates are based on: (1) empirical averages of actual lengths at various ages at times of capture; (2) lengths at various annuli calculated by the method assuming direct proportion of body-lengths to scale length; (3) lengths at various annuli from calculated relationship of body-scale ratio. Scale dimension used in (2) and (3) was distance from estimated center of scale focus to anterior scale margin, along that imaginary line most nearly bisecting the scale. Fish lengths are total lengths to nearest 0.1 inch.

The scale method is validated for the

TABLE 2.—LENGTHS OF GIZZARD SHAD AT VARIOUS AGES IN BEAVER DAM LAKE AS DETERMINED BY VARIOUS METHODS

Method of Length Estimation	Average Total Lengths in Inches				
	Age-groups (Numbers of Annuli)				
	0	I	II	III	IV
	Year of Life				
	1	2	3	4	5
Empirical	3.4 (August) 5.8 (December)	9.6	11.1	13.2	15.0
Assumed Body-scale Ratio 1:1	...	5.6	10.1	12.2	14.2
Calculated Body—Scale Relationship	...	6.2	10.3	12.1	14.0
Size Range at capture	1.5–4.4 (August) 4.7–7.4 (December)	8.4–10.8	9.4–13.2	11.6–14.8	14.5–15.7
Number of Fish	259	98	240	56	16

gizzard shad by: (1) failure of young to show annuli as late as December of their first year of life; (2) by the agreement between average length of December young and calculated lengths at the first annulus (Table 2); and (3) by the fact that increase in number of annuli is systematically associated with increase in length (Table 2).

Beaver Dam Lake appears to exemplify a very favorable habitat for gizzard shad, at least as far as growth is concerned (Table 2 and Fig. 1). Young-of-the-year fish appear to complete their growth before December by attaining nearly 6 inches of length. Average length at first annulus, which is formed in the spring, also approximates 6 inches. At succeeding annuli, though growth rate has become slower, substantial increments are evidenced by the mean lengths reached: II, about 10 inches; III, about 12 inches, and IV, about 14 inches.

In the gizzard shad, as in many other

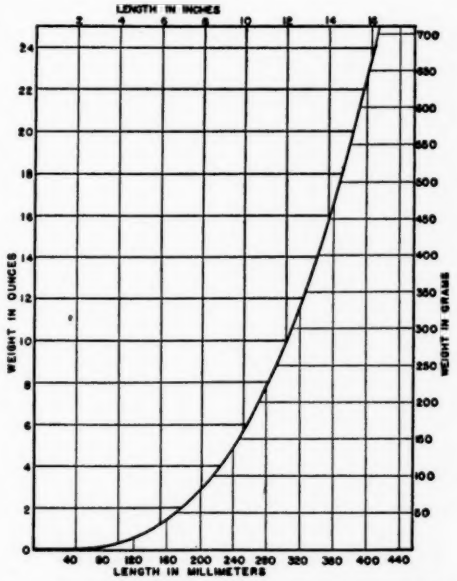

FIG. 1. Calculated length-weight relationship in the gizzard shad (for total length measurements).

fishes, the formula $L = a + bS$ gives a satisfactory expression of the relationship between scale length (measured

along anterior, imaginary mid-radius, as indicated) and length of fish where

L = total length of fish
a = a constant (= 1.2129, as determined empirically)
b = a constant (= 0.0509, as determined empirically)
and S = scale length.

The magnification of the scale employed in our analyses is 41.7 diameters.

The relationship between length and weight in the gizzard shad may be expressed, with reasonable satisfaction by the formula

$$W = CL^n$$

where

W = weight
C = a constant
L = length
n = an exponent.

For this species in our sample the value of Log C is -2.2789 and the value for n is 3.034 when total length in inches and weight in ounces are used. This formula also gives a satisfactory fit for several other kinds of fishes. In the gizzard shad the fit is good excepting in the larger size groups where the numbers of fish are small (Fig. 1).

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THE DISTRIBUTION AND PRODUCTION OF MUSKRATS ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE

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The Montezuma National Wildlife Refuge, Seneca County, New York was purchased during the summer of 1937. It was later enlarged slightly and now totals 5,819 acres (Figure 1). The location is a natural marsh area near the north end of Cayuga Lake.

The primary purpose of the Refuge is to serve as a resting, nesting and feeding area for migratory waterfowl, but all wildlife species of the region are given consideration.

The original natural marshes had been partially drained by the construction of the Barge Canal system, so it was necessary to improve the habitats and to establish controlled levels of the water. Nearly eight miles of earthen dike were constructed by the Civilian Conservation Corps between 1938 and 1941. This flooded two large sections of the Refuge with water 1½ to 3 feet deep over most of the area, increasing

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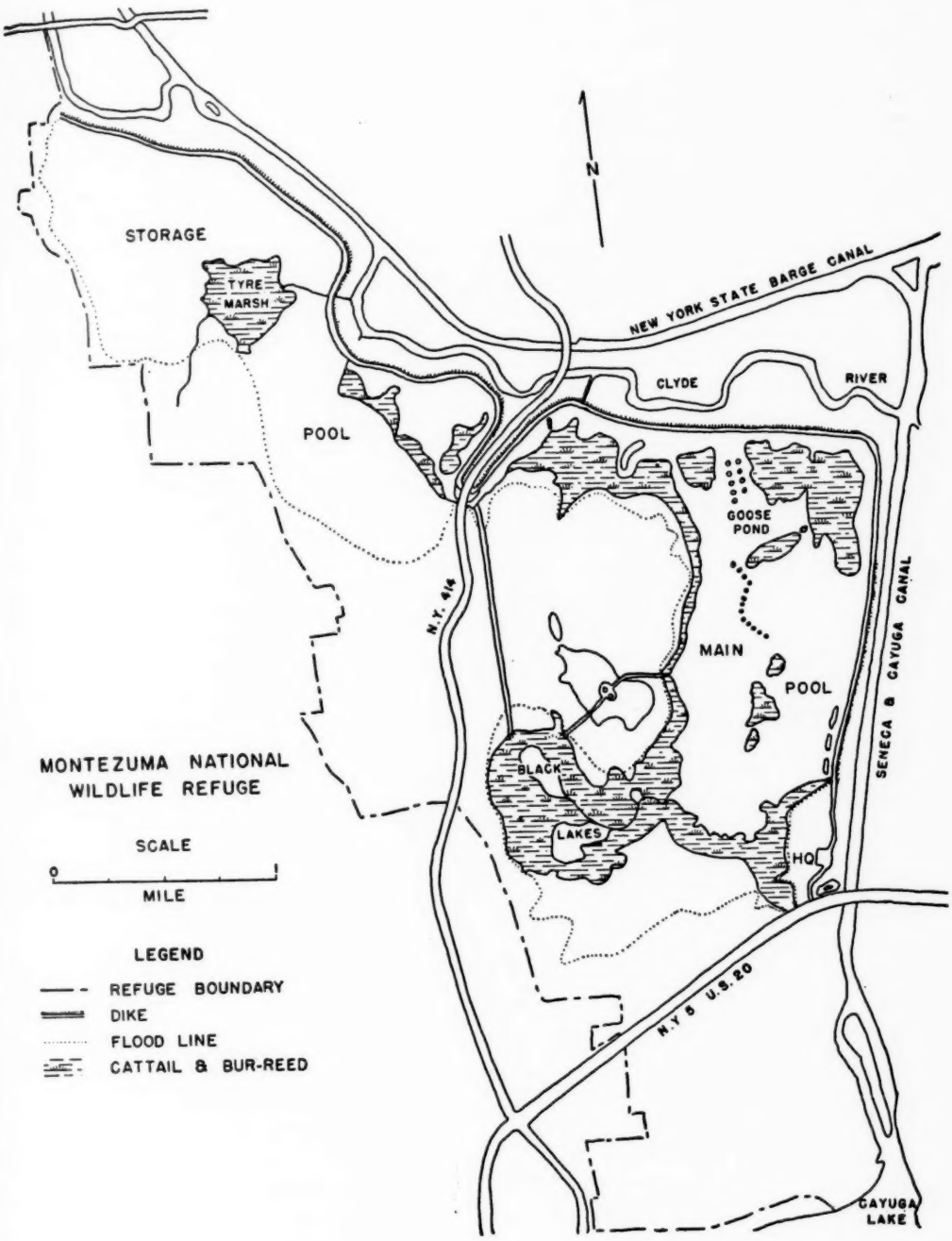

FIG. 1. The Montezuma National Wildlife Refuge

to about 9 feet deep in the channels constructed for deep water circulation. A main pool of nearly 1600 acres was completely flooded in the spring of 1942. Two small ponds (Black Lake and Goose Pond) occupied part of this area before flooding and approximately 200 acres of cattail (*Typha latifolia*, *T. angustifolia* and *T. glauca*) surrounding them and their drainage channels provided the nucleus of marsh vegetation for the newly flooded area. Most of the area had been covered with marsh hay (*Spartina pectinata*) or had been drained for farming purposes. The second section of about 1200 acres was completely flooded in the spring of 1943. This was to serve as a storage pool and all but about 260 acres were covered with a red maple—elm swamp.

Extensive changes in the vegetation have occurred and are continuing. Within two years most of the main pool became a cattail marsh. During the three years following this, the cattail areas became reduced due to the deeper water in the central portion of the pool and the activities of a heavy muskrat population. The last few years have witnessed a steady increase in the stands of bur-reed (*Sparganium eurycarpum*) particularly on areas in the northern part of the main pool formerly covered with cattails. However the central portion of the main pool that had become open water is now returning to cattail.

The open areas within the storage pool were slower in developing marsh vegetation. One area near the main pool became completely covered with cattail by 1946 but a very high muskrat population and a rise in the water level caused a decrease in vegetation. This change in the water level was necessary to improve the habitat for waterfowl and to permit greater storage of water. Another smaller open area, the Tyre Marsh, has maintained its vegetation to the present. The wooded areas within this impoundment are becoming thinned by the blowing down of the dead trees. Although primarily a storage pool to maintain the level of the main pool, the area has served very well to shelter waterfowl and other species of wildlife. A large rookery of great blue herons has been located in the woods for several years.

The variety of the habitats that were flooded has brought about an equal variety of habitats now. This also made possible the use of the Refuge by waterfowl from the first year of flooding and the variations in the habitat since that time has made the area attractive to a wide variety of species.

It is to be expected that this marsh area would be readily accepted by the muskrats. The portion that had supported marsh vegetation before flooding had been occupied by a good population of muskrats, possibly about 1500. No trapping was permitted from 1937 until 1943 and with a slight raise in water level due to dike construction, the population probably doubled itself by 1941. The flooding of the main pool in the spring of 1942 followed by a rapid expansion of the marsh vegetation made possible the increase in the population to 6 – 8 thousand. They were very active in the dike and it became necessary to trap muskrats and dig them from burrows to prevent further damage. It was decided that a harvest should be made the following season, January 1 to March 20, 1943.

TABLE 1.—THE MUSKRAT HARVEST
Catch by Month, Number of Trappers, Price, Value and Population

Year	Jan.	Feb.	Mar.	Total	Number Trappers	Average Price	Total Value	Est. Pop. in Thousands
1943.....	297	564	643	1,504	3	2.60	$3,910.40	10
1944.....	1,841	1,252	866	3,959	3	3.57	14,133.63	20–22
1945.....	2,099	2,599	3,261	7,959	5	2.30	18,305.70	20–30
1946.....	4,594	2,282	748	7,624	5	2.30	17,535.20	20–21
1947.....	3,979	2,245	677	6,901	6	3.75	25,878.75	14–18
1948.....	2,437	914	428	3,779	5	3.90	14,738.10	10–12
1949.....	1,285	238	0	1,523	3	3.00	4,569.00	4–5
1950.....	——	876	398	1,274	2	2.75	3,503.50	4–5
1951.....	——	1,958	507	2,465	3	3.71	9,141.44	7
Total....	16,532	12,928	7,528	36,988	35	$3.02	$111,715.72	
Average per trapper per year							$1,595.94	

During the next nine years 36,988 muskrats were taken from the marsh. The breakdown of these harvests is shown in Table 1 along with the number of trappers, the average price received for the fur and the total value. Nearly $112,000 was received from these harvests, an average of $3.02 per pelt. A house count was made each winter by the Refuge personnel and the estimated population is shown in this table. Although the number of trappers varied, the catch for most years can be divided into four natural sections of the marsh as shown in Table 2. They are arranged in the order of their development into good muskrat habitats, Black Lake section being well developed at the beginning of trapping and Tyre Marsh recently reaching its peak of development. The shift in the harvest on the different sections from year to year coincides with the development of the marsh vegetation. Each section in turn supported a high muskrat population for about two years and then gradually deteriorated due to the action of the muskrats and in some cases the unfavorable depth of water. In this manner, as one section came to produce fewer muskrats, another section was in its peak production, so that the population on the Refuge remained high until most sections had nearly completed the cycle and had become somewhat stabilized in their densities of vegetation and muskrats. Black Lake did not fall in its production to the degree witnessed in the other sections. All sections are undergoing improvement at the present time.

Of the total harvest, 34,711 muskrats

TABLE 2.—YEARLY HARVESTS FROM THE DIFFERENT SECTIONS OF THE REFUGE

Year	Black Lake		N & E Main Pool		Storage Pool		Tyre Marsh	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
1943.....	927	61.6	550	36.6	27	1.8	——	——
1944.....	1,824	46.1	2,008	50.7	127	3.2	——	——
1945.....	1,560	19.6	4,666	58.6	1,733	21.8	——	——
1946.....	1,513	19.8	4,531	59.5	1,580	20.7	——	——
1947.....	1,475	21.4	2,420	35.1	2,074	30.1	932	13.4
1948.....	830	21.9	944	25.0	1,000	26.5	1,005	26.6
1949.....	514	33.7	501	32.9	(508		33.4)	
1950.....	No division possible							
1951.....	723	29.3	665	27.0	616	25.0	461	18.7

were sexed and the sex ratios are given in Table 3. As shown by Dozier (1950) there was a general downward trend in the percentage of males during the first few years followed by a leveling off. However the last three years have shown a similar increase in male percentages. The percentage of males reached its lowest point in 1948. The reason for this is not known. It was thought that the weather might have influenced it since the catch was taken during a very severe winter, but winters of varying severity have shown similar results. Two severe winters, 1947 and 1948, produced 94 and 89 males per 100 females while two mild winters, 1946 and 1949, produced 92 and 107 males per 100 females.

There is a tendency for the percentage of males to increase as the season progresses and approaches the breeding season. This has increased from a total figure of 93 males: 100 females in January to 107 males in February and to 120 males in March. Attempts to trap in April have resulted in very few females being taken. This can be attributed in part to the variation in the activities of the two sexes during the different seasons.

Table 4 shows that the distribution of the catch within the season can change the over-all sex ratio for the season. For the total number sexed during the nine years, 46.5 per cent were taken in January, 34.2 per cent in February and 19.3 per cent in March. If the number taken from each month had been in proportion to the number of trapping days in each the sex ratio would have been slightly greater than the 102 males: 100 females.

TABLE 4.—DISTRIBUTION OF THE SEXED MUSKRATS WITHIN EACH SEASON BY PER CENT

Year	January	February	March
1943.....	0.0	0.0	100.0
1944.....	46.6	31.6	21.8
1945.....	27.6	34.3	38.1
1946.....	61.1	29.7	9.2
1947.....	58.0	32.8	9.2
1948.....	64.5	24.2	11.3
1949.....	84.4	15.6	0.0
1950.....	—	55.7	44.3
1951.....	—	79.4	20.6
Total.....	46.5	34.2	19.3

It is of interest to examine these figures for each season. The high percentage of males in 1943 may be due to the fact that only March muskrats were sexed. The 1944-season shows a more equitable distribution when it is considered that trapping is permitted only in part of March. For this year, however, February has an abundance of males and March is low. In 1945 the largest catches came in March when the

TABLE 3.—SEX RATIO BY MONTH AND SEASON (Males: 100 Females)

Year	January	February	March	Total	Total No. Sexed
1943.....	—	—	133	133	374
1944.....	119	147	114	124	3,951
1945.....	104	100	118	107	7,425
1946.....	84	102	121	92	7,478
1947.....	91	95	116	94	6,797
1948.....	83	90	125	89	3,779
1949.....	102	138	—	107	1,523
1950.....	—	107	112	109	919
1951.....	—	121	141	125	2,465
Total.....	93	107	120	102	34,711

males were in the majority. The years 1946, 1947, and 1948, with varying weather conditions, had their catch distribution about the same. In each case, the very high catch in January when females were predominant resulted in a low season percentage of males. The 1949-season was short due to the early completion of trapping quotas so the January ratio had great influence on the season's total. However, the males were still more numerous than the previous year due to an unexplainably high percentage of males in January. The season did not open until February in 1950 which resulted in a somewhat higher male percentage. In 1951 the males were extremely abundant, approximating the 1944 ratios.

In considering the entire 34,711 sexed muskrats from the Refuge it can be seen that there is considerable variation in the distribution of the catch from year to year and within each season (Table 4), and also variation in the sex ratios for these months and seasons (Table 3). These two factors determine the final sex ratio of the muskrats on the area and are influenced by such things as weather, seasonal activities of the animals, trapping activity, development of the habitat, and probably many other things not understood at this time. Although the distribution of the total sexed muskrats does not exactly coincide with the relative length of each period, the relationship is close enough to lead one to believe that the sex ratio of 102 males: 100 females is accurate for the harvest season.

Table 5 gives the average weight of the muskrats that were sexed during the nine-year period. There are some logical reasons for the variation shown. A fairly uniform difference between the average weights of the males and females appears—the males weighing four ounces more than the females.

Accurate information on age distribution is available for only the 1948 trapping season. However, some assumptions can be made for other seasons. When Dozier (1945) made his study on the Refuge in 1944, he found that the small number taken from the storage pool weighed much less than those from the main pool and had little or no fat on their carcasses. This he credited largely to a poorer food supply on the newly-flooded area. In subsequent years, the area developed into an excellent habitat and it now produces muskrats of the same size as the other sections of the marsh. This is due not only to the improved condition of the habitat but also to the fact that older

TABLE 5.—AVERAGE WEIGHT IN POUNDS OF MUSKRATS BY SEX, MONTH AND SEASON

Year	January		February		March		Total		
	Male	Female	Male	Female	Male	Female	Male	Female	Total
1943.....	—	—	—	—	3.22	3.07	3.22	3.07	3.24
1944.....	3.39	3.23	3.59	3.35	3.85	3.45	3.56	3.31	3.44
1945.....	3.13	3.06	3.18	3.03	3.14	2.91	3.15	2.99	3.08
1946.....	3.10	2.75	3.35	3.06	3.46	3.14	3.22	2.87	3.04
1947.....	3.20	2.99	3.39	3.18	3.23	3.03	3.26	3.06	3.16
1948.....	2.98	2.79	2.89	2.71	2.87	2.63	2.94	2.76	2.84
1949.....	3.02	2.84	3.08	2.96	—	—	3.03	2.86	2.94
1950.....	—	—	2.87	2.76	3.44	3.20	3.13	2.95	3.04
1951.....	—	—	3.19	2.97	2.79	2.59	3.10	2.89	3.01
Total	3.14	2.90	3.26	3.04	3.26	3.00	3.21	2.97	3.09

age-calsses are present in greater proportions in the population. In wildlife populations that are increasing rapidly, the younger age classes are dominant. The variation in the distribution of the catch from year to year and the development of the several sections of the marsh undoubtedly has had its influence on the weights of the muskrats.

There appears to be a decided increase in weight from January to February followed by slight increases or decreases in March. This results in somewhat lower average weights for seasons with a large portion of the catch in January.

The 1943 muskrats were heavy (3.24 lbs.) due to a large percentage of old adults from an untrapped population, trapping of established habitats and records from only the end of the season when the majority were heavier males.

The 1944 muskrats averaged heavier (3.44 lbs.) due to a large percentage of old adults, improving muskrat habitats and a majority of males throughout the season.

The 1945 muskrats were considerably lighter (3.08 lbs.) due to increased trapping in new and poorer habitats which were producing a greater proportion of young muskrats with little or no fat deposition. Males being in the majority prevented the average from falling even lower.

The 1946 muskrats were slightly lighter (3.04 lbs.) due in part to a heavy catch in January when the majority were females. This decrease in weight was partly offset by the steady improvement of the habitats.

The 1947 muskrats were somewhat heavier (3.16 lbs.) in spite of a heavy catch in January when the majority of the muskrats were females. The weight increase is probably due to the fact that this year saw a peak production in the storage pool of muskrats with heavy fat deposition and large size.

The 1948 muskrats again were lighter (2.84 lbs.) due to a general decline in the condition of all the habitats except the Tyre Marsh which was improving steadily. The January harvest which made up 64.5 per cent of the catch contained an abnormally high proportion of females, 83 males: 100 females, resulting in further decrease in the average weight.

The 1949 muskrats were a little heavier (2.94 lbs.) in spite of no catch in March and a small catch in February. However, the majority of the January muskrats were males and some improvement of the habitat was noted. Also with the Tyre Marsh nearing its peak and producing large muskrats even though its acreage is small helped some in increasing the average.

The opening of the 1950-season on February 1 instead of January 1 eliminated the lighter January muskrats. This and improved habitat conditions caused an increase in the muskrat weights (3.04 lbs.)

The 1951-season also started February 1 and the weights remained about the same (3.01 lbs.). Males appeared in the greatest numbers since the first two years of trapping.

Although the percentage of males have increased during the latter years to the levels of the first few years of trapping, the average weights have remained about the same. With the exception of the 1943 and 1944 weights the season averages have been close to

3 lbs. and it is believed that future weights should remain about this figure.

SUMMARY

Since its development as a waterfowl area, the Montezuma National Wildlife Refuge has become one of the best muskrat producing marshes in New York. The relationship of muskrat populations to vegetational development is very definite and the effect of the muskrat on the vegetation is pronounced.

During the nine trapping seasons, 1943 to 1951 inclusive, 36,988 muskrats were removed from the Refuge. These have been valued at $111,715.72 which is equal to an average of $1,595.94 for each trapper each year for his half of the catch.

The sex ratio during the first three years was greater for males followed by three years of female majority. The last three years have returned to increased percentage of males. The 34,711 that were sexed and weighed have a sex ratio of 102 males: 100 females.

The average weight has fallen from a high of 3.44 pounds in 1944 to a low of 2.84 pounds in 1948. The average for the nine years is 3.09 pounds. It is believed that future weights should average about 3 pounds.

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PUBLIC HUNTING ON THE BEAR RIVER MIGRATORY BIRD REFUGE, UTAH

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The problem of insuring continued hunting of waterfowl for the increasing number of hunters requires that all available information be assembled to aid in an adequate management program. Of the many aspects of the problem, some practices, like the improvement of existing areas and the development of additional waterfowl habitat, while of primary importance, do not produce immediate results. Restrictive waterfowl hunting regulations, in contrast, are decisive practices that can be applied for immediate effect. It is the purpose of this paper to describe the results of waterfowl hunting as it is managed on the Bear River Migratory Bird Refuge, with special attention to the relationship between hunting regulations, bag data, and waterfowl populations.

Since the area had been in use by natives long before the advent of the early trappers and was hunted over with further enthusiasm during the days of market-hunting, there is a tendency to compare preregulation conditions with those of more recent times under re-

striction. Yet few hunters today fail to recognize that regulation is necessary, and sportsmen generally express confidence in the ability of the responsible agencies to establish equitable measures.

As would be expected, localized conditions create problems peculiar to certain areas. An example would be the depredation on farm crops which are near or occupy former extensive marshes. Other localities may harbor excessive amounts of botulinus toxin, which, in turn, may cause locally a considerable loss of bird life. Under such extraordinary conditions it is sometimes difficult for an individual to visualize the importance of restrictive regulation or to interpret the over-all problem on a continental basis. Nevertheless, the practice of internationally regulating waterfowl hunting is generally recognized as sound and necessary.

THE CHECKING STATION

The Bear River Migratory Bird Refuge is one of the few Federal refuges where hunting is allowed. It is different from most other western public marshes in that only part of the area is open to hunting and additional restrictive regulations are set up and enforced. This refuge consists of 64,000 acres, including some marsh formerly controlled by private clubs. To compensate for State lands taken over by the Federal Government, an agreement was made whereby 40 per cent of the impounded area, or approximately 12,000 acres, would be open to public hunting. The public hunting area is in two separate blocks. Actually, the setup has many of the advantages that private clubs have, and it provides choice hunting for those hunters willing to shoot under strict regulation.

Each hunter is required to present State hunting license, Federal hunting stamp, and gun for inspection as he checks in. The name and address and time of entry are recorded, and a numbered slip is given each hunter. The slips are returned when the hunters check out, and on the back of each slip is recorded such information as the number of each species, sex and age of the birds bagged. These data, in turn, are compiled to produce detailed and complete seasonal hunting reports. The procedure also serves as a check on hunters who fail to leave the marsh. Occasionally accidents occur or hunters become lost. When this happens, effort is made by refuge personnel to be of assistance. Information regarding regulations is posted, and additional instruction is given to newcomers. The entire operation is of little inconvenience, but with other restrictions and effective enforcement, the area is no happy hunting ground for lawbreakers.

METHODS OF HUNTING

Shooting from blinds is the most common type of duck hunting on the area, although there is some jump shooting by foot hunters. Since the area is public, there is no point in constructing fancy or permanent blinds. The most common blinds are those put up by the hunters in the field and are made of materials at hand, usually cattails or bulrushes, which are cut and placed to augment standing clumps. Camouflaged boat blinds are also often used for cover. These rough attempts at concealment are at least partly effective, but prob-

ably more attention to better blind building would pay off in more ducks bagged.

Decoys used may be mere mounds of mud, profiles, blocks, or the convenient collapsible rubber types. The ingenuity displayed in the manufacture of some of the decoys is cause for wonder.

Boats vary from home-made kayaks to airthrust boats powered with light airplane motors. Each type has its particular merits, but inboard motors are not practicable, except in the channels, because of the shallow water in the marsh area. Considering such factors as cost, practicability, safety, etc., probably the most desirable type of boat is a shallow-draft, flat-bottomed boat powered with an air-cooled motor having an external drive or propeller shaft. This motor allows power in a minimum depth of water, but even then it is usually necessary to pole some distance. Aluminum boats are becoming more popular and, though more expensive, are very satisfactory in that they are light in weight and require little maintenance.

Instead of using boats, many hunters travel on foot. However, those who travel on foot have less chance of success, mainly for the reason that areas accessible to them are limited, and on Sundays and holidays there is a tendency to crowd. It is common on those days for hunters to rise up and shoot at birds long before they are within range. In this way a ridiculous number of shots may be fired at a single bird without once allowing it to approach within shotgun range.

The deluxe hunting on the area is done with guides who provide most of the equipment and all of the labor. This type of hunting, while quite satisfactory, is limited because of the expense involved and the ready availability of memberships in local clubs.

Two private hunting clubs adjoin the Refuge. One has only a small area, and most of the members hunt on the Refuge. The other contains approximately 11,000 acres of choice, privately-owned marsh, which in effect serves as a welcome addition to the Refuge. The latter club enjoys outstanding shooting. A summary of the 1948 season hunting data produced by private clubs of the State and the State public shooting areas is given in Table 1.

The hunters using the Refuge are a mixed lot; it is not uncommon for a man dressed in business clothes to register. The novices, with their low chance of success, tend to lower the total bag

TABLE 1.—SUMMARY OF WATERFOWL HUNTING DATA FROM PRINCIPAL MANAGED AREAS OF UTAH 1948

Area	Hunter Days	Waterfowl Bagged	Average Individual Bag
Bear River Migratory Bird Refuge	4,682	10,715	2.29
State Public Shooting Grounds	1,175	1,069	0.91
Ogden Bay Refuge	10,312	14,072	1.36
Farmington Bay	11,157	8,415	0.75
Private Clubs	9,669	31,450	3.26
TOTALS	36,995	65,721	1.78

Data compiled by Noland F. Nelson under Utah Federal Aid Project 29-R.

averages. In contrast, there are those who possess remarkable skill and are well equipped. As would be expected, the birds will favor the less accessible and closed areas. Often the hunters fail to understand this, and sometimes there is agitation to have the position of the open area changed. However, it has been determined that the present open units contain the best and most desirable area, and the birds would favor the closed areas regardless of their location. Geographically and physically, the Refuge is situated so as to attract an abundance of birds, and while it also attracts many hunters, the hunting is sufficiently good to maintain the continued popularity it deserves. The total bag is, at the same time, sufficiently low in relation to the population that the Refuge continues to be a great conservation area.

SEASONS AND OPENINGS

In 1934 a system of permitting hunting on Friday, Saturday, and Sunday only, or split week, was put into practice (Table 2). This had no apparent effect on the number of hunters, the number of ducks killed, or the bag averages. Subsequent years saw a resumption of the conventional full-week hunting. It is easier to manage an area where the number of hunters will be distributed over the entire week, and the ducks would not be subjected to recurring opening days.

During the 1948 season it was found that of 4,682 hunter days spent on the marsh, 3,438 or 74% were hunted on weekends and holidays. Thirty-seven per cent, or 1,761, of the total number of hunter days were spent on the six Sundays of the season (Figure 2).

The implications here are that any restriction affecting the weekend hunting would strongly influence the number of hunters and, as a consequence, the number of waterfowl bagged; however, curtailment of weekend hunting would be a discrimination against the workingman and should not be practiced. The noontime weekday opening, on the other hand, is not sufficiently restrictive to be

TABLE 2.—BEAR RIVER MIGRATORY BIRD REFUGE, UTAH OPEN SEASONS AND EXTENT OF BAG LIMITS FOR THE SEASONS OF 1932 TO 1948

Year	Length of Season	Dates Open	Total Bag	Mixed Bag
1932	60 days—continuous	Oct. 1 to Nov. 30	15	10 and 5
1933	60 days—continuous	Oct. 16 to Dec. 15	12	8 and 4
1934	30 days—split, Fri.-Sat.-Sun.	Oct. 12 to Dec. 16	12	7 and 5
1935	30 days—continuous	Oct. 21 to Nov. 19	10	3 shell law
1936	30 days—continuous	Nov. 1 to Nov. 30	10	
1937	30 days—continuous	Nov. 1 to Nov. 30	10	
1938	45 days—continuous	Oct. 15 to Nov. 28	10	7 and 3
1939	45 days—continuous	Oct. 22 to Dec. 5	10	7 and 3
1940	60 days—continuous	Oct. 16 to Dec. 14	10	7 and 3
1941	60 days—continuous	Oct. 16 to Dec. 14	10	7 and 3
1942	70 days—continuous	Oct. 15 to Dec. 23	10	7 and 3
1943	70 days—continuous	Oct. 15 to Dec. 23	10	7 and 3
1944	80 days—continuous	Oct. 14 to Jan. 1	15	10 and 5
1945	80 days—continuous	Oct. 13 to Dec. 31	10	
1946	45 days—continuous	Oct. 26 to Dec. 9	7	
1947	35 days—continuous	Oct. 21 to Nov. 24	4	noon opening
1948	40 days—continuous	Oct. 29 to Dec. 7	5	noon opening

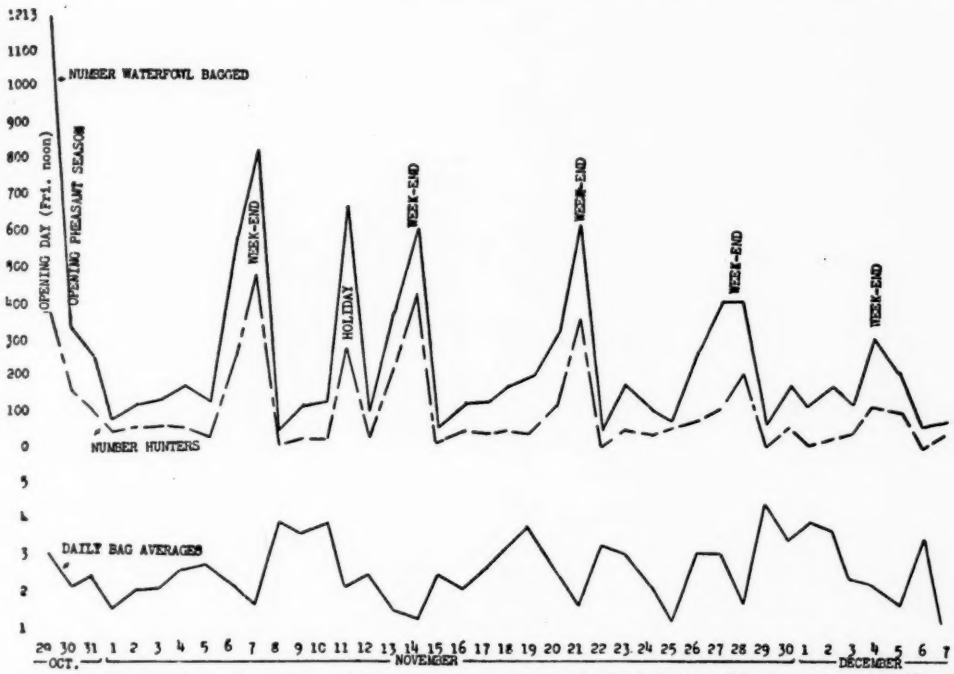

FIG. 2. Comparison of number of hunters to number of ducks killed and bag averages, 1948

resented; yet it is an effective conservation measure (Table 3).

The noontime weekday opening initiated in 1947 and continued in 1948 was an important factor in the number of hunters and the number of ducks killed. This is shown by the fact that the 391 hunters for the 1948 opening day, though more than double the number for 1947, was far below the 744 hunters registered on the early morning opening of 1946 (Table 3). The bag averages on the opening days for 1946, 1947, and 1948 were 3.46, 3.50 and 3.10 respectively. They indicate that the saving of ducks was the result of fewer hunters rather than any decrease in bag averages.

The split-season practice, while not in effect in Utah since 1934, was influential here in 1948 because the split season of the adjoining States would permit hunters from around this area in northern Utah to hunt in near-by Wyoming as early as October 8, then in Utah during November, and in Idaho until January 8. The main objections here are that the birds are hunted over too long a period; only the more fortunate hunters can participate, and the problem of enforcement is increased. The small number of hunters moving from one State to another is not considered important except as it contributes to the total influences. It is necessary to establish a date differential for the various zones; however, it is proposed that the span of the seasons be limited to shorter periods. Note from Figure 3 that a split season would have little advantage for the hunter in this area unless it permitted an earlier season. This is less a point for the split season

TABLE 3.—These figures show that for a period of seventeen years an average of 15.25% of the total kill is taken on the opening day of the season. They further indicate that when the season opens on a Saturday or Sunday 17.92% of the total kill for the season is taken on first day; also that 13.58% of total kill is taken on first day when season opens on a week day. However, when season opened at noon on week day, as was case the last two years, the kill on opening day dropped to 7.04% and 11.32% of total kill for the season.

Year	Opening Day	No. of Hunters First Day	No. of ducks killed first day	Total kill for season	Percentage of kill opening day to total kill	Average kill for Season
1932	Sat. Oct. 1	248	1,217	11,218	10.84%	4.814
1933	Mon. Oct. 16	365	2,013	12,361	16.29	3.220
1934	Fri. Oct. 12	350	1,463	7,559	19.35	4.289
1935	Mon. Oct. 21	123	544	2,770	19.64	3.037
1936	Sun. Nov. 1	285	1,154	5,488	21.03	4.170
1937	Mon. Nov. 1	220	1,434	7,809	18.36	3.084
1938	Sat. Oct. 15	403	2,189	13,598	16.10	4.477
1939	Sun. Oct. 22	564	2,401	11,581	20.73	2.727
1940	Wed. Oct. 16	519	2,095	15,816	13.25	3.377
1941	Thurs. Oct. 16	546	3,090	23,467	13.17	3.570
1942	Thurs. Oct. 15	699	2,728	16,683	16.35	3.700
*1943	Fri. Oct. 15	157	1,180	16,816	7.02	4.612
1944	Sat. Oct. 14	519	1,990	17,063	11.66	4.373
1945	Sat. Oct. 13	651	3,927	17,603	22.25	3.859
1946	Sat. Oct. 26	744	2,680	10,296	26.03	2.255
1947	Tues. Oct. 21 Noon	169	591	8,390	7.04	2.659
1948	Fri. Oct. 29 Noon	391	1,213	10,715	11.32	2.290
TOTALS			31,909	209,233	Av. 15.25%	

* Only a few hunters registered on opening day due to war, gasoline rationing, and shortage of shotgun shells.

than it is for an earlier season. In this connection, it should be mentioned that during an early season in a year of extreme botulism sickness, too many afflicted birds would be taken. This in itself would not be serious, for cooking destroys the toxin, but many of the ducks would be unduly vulnerable and in an emaciated condition.

Regulations governing the length of the season are probably the most influential measures, mainly because they dictate the number of hunter days to be spent in the field. It has been shown that the number of hunters determines the kill more effectively than does the next important factor of bag limits (Table 4). Put in another way, even though the regulations vary greatly, bag averages follow a comparatively even trend. Extreme averages are about 1.3 birds from the 1932–1948 average of 3.5 birds per hunter-day, and a hunter-day continues to approximate seven and one-half hours. In contrast, the total number of hunters differs widely from year to year. Since the number of hunters is shown to have been the principal factor in the total number of ducks bagged, then the number of hunter-days is the variable factor at which restrictive regulation should be aimed.

BAG LIMITS

The extent of the bag limits is of popular interest, and, if not controversial, is at least the subject of much discussion. It is fortunate that regulations pertaining to bag limits can be made on a flyway basis, the nearest approach to allowing an equitable take on

the basis of abundance. Illustrated in Figure 1 is the fact that, considering the present and immediate past population, there is little value or object in setting a high bag limit. High limits, however, have popular appeal, and they

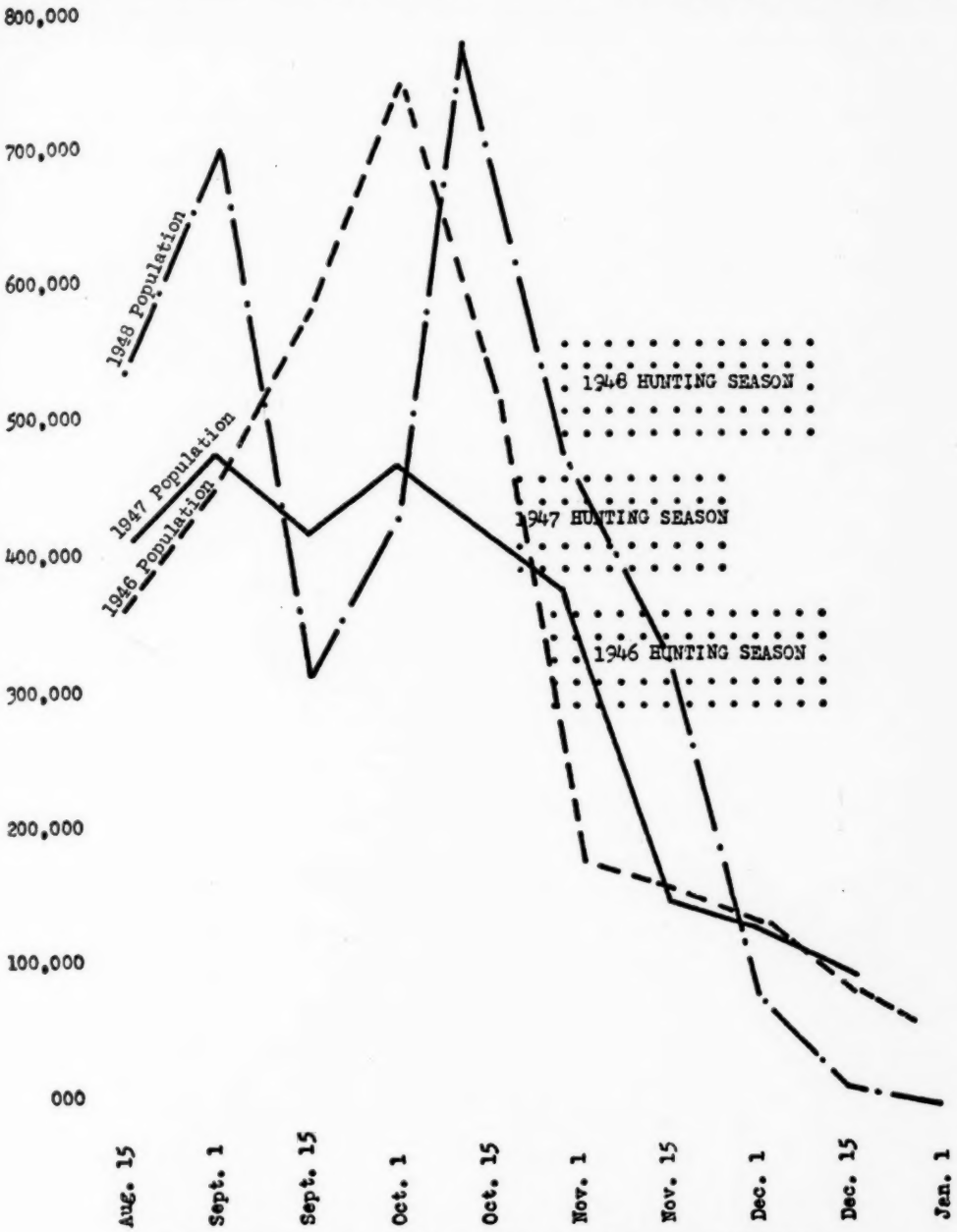

FIG. 3. Presence of waterfowl in relation to hunting seasons 1946-1948

are often of psychological pleasure to the hunter. On the other hand, it is surprising how many hunters prefer a low bag limit so that they can more easily attain the distinction of bagging the limit. Figure 1 indicates that bag averages vary surprisingly little in relation to bag limits. It follows that bag limits are effective only in relation to the proficiency and honesty of hunters and the

TABLE 4.—COMPARATIVE TABLE SHOWING BY SPECIES THE NUMBER OF WATERFOWL TAKEN ON AREA OF REFUGE OPEN TO PUBLIC HUNTING AND THE NUMBER OF HUNTERS FOR THE SEASONS 1932 TO 1948

Species	TOTAL KILL								
	1932	1933	1934	1935	1936	1937	1938	1939	1940
Pintail	3185	4193	2296	571	2106	2873	4012	3477	4023
Mallard	692	858	952	658	854	1519	2483	1673	3017
Baldpate	801	772	516	356	150	360	441	604	1263
Golden-eye	133	302	187	62	48	80	64	28	105
Gadwall	735	620	272	145	302	750	785	1133	565
Shoveller	1500	1877	1311	271	733	692	1541	1367	2111
Cinnamon Teal	292	48	22	12	57	38	171	66	19
Green-w. Teal	3090	2678	1553	455	1082	1343	2689	2748	3628
Scaup	57	204	50	64	59	71	110	26	84
Redhead	460	210	52	61			472	75	258
Canvasback	159	123	136	43			444	101	379
Bufflehead							121	75	159
Ruddy							55	10	13
Canada Goose	36	67	28	19	11	25	71	23	47
L. Snow Goose	78	363	134	24	10	16	70	92	70
Mergansers						36	53	57	52
Miscellaneous		46	50	29	76	6	16	26	23
TOTALS	11218	12361	7559	2770	5488	7809	13598	11581	15816
No. Hunters	2332	3839	2298	912	1316	2532	3037	4247	4685
Av. kill per man day	4.814	3.220	3.289	3.037	4.170	3.084	4.477	2.727	3.377

Species	TOTAL KILL							
	1941	1942	1943	1944	1945	1946	1947	1948
Pintail	8829	6416	7549	6304	6952	2868	2531	3234
Mallard	3235	1672	2013	2277	1137	947	848	1329
Baldpate	687	592	630	817	719	406	229	379
Golden-eye	83	85	28	74	47	46	38	132
Gadwall	1232	468	1067	846	1127	714	647	526
Shoveller	2282	2576	2160	3327	2151	1006	1315	1375
Cinnamon Teal	121	68	62	140	190	63	68	40
Green-w. Teal	5002	4136	1700	2503	4465	3656	2230	3367
Scaup	93	64	26	83	83	60	23	24
Redhead	944	90	417	129	192	120	75	52
Canvasback	599	244	1019	372	202	197	282	118
Bufflehead	145	92	8	42	100	64	36	48
Ruddy	81	12	12	18	6	7	4	22
Canada Goose	65	102	86	52	72	66	38	38
L. Snow Goose	40	28	5	43	122	41	14	8
Mergansers	21		26	22	30	27	9	13
Miscellaneous	8	38	8	14	8	8	3	10
TOTALS	23467	16683	16816	17063	17603	10296	8390	10715
No. Hunters	6573	4509	3646	3902	4562	4565	3155	4682
Av. kill per man day	3.570	3.700	4.612	4.373	3.859	2.255	2.659	2.289

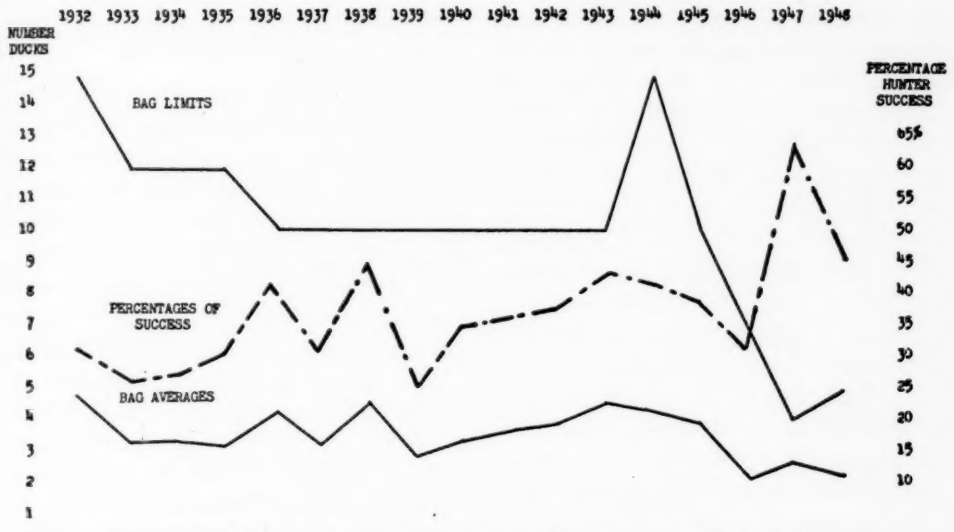
1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948
NUMBER DUCKS
PERCENTAGE HUNTER SUCCESS
BAG LIMITS
PERCENTAGES OF SUCCESS
BAG AVERAGES

FIG. 1. Percentages of hunter success based on ratio of bag limits to individual bag averages

density of the population. Since the limits are set according to the estimated population, it is revealing that in 1932, with a bag limit of 15, the bag average of 4.8 birds was less than one duck above those of 1936–1938–1943 when the limit was 10 (Table 4). In 1944 the limit of 15 ducks resulted in a daily average individual kill of 4.37 birds, which was a lower average than for the preceding year when the limit was 10. It follows also that the percentage of hunter success rises as the limits are lowered, and the ratio of bag averages to bag limits is widened by increases of the bag limits. The foregoing suggests a point above which bag limits have little effect. They affect mainly the better hunters shooting in areas of abundance. However, if the desired number of ducks is saved by bag limits, and undoubtedly the total kill is affected, the law has value. In this connection bag and season become closely related, and the idea that the season may be shortened while increasing the bag limit is worthy of consideration.

SPECIAL PROTECTION FOR CERTAIN SPECIES

At times a special consideration for dwindling species is desirable. In species differentiation it must be recognized that very few hunters can identify ducks in hand and still fewer can identify them in flight. This fact must be advanced whenever a species differential in the bag limit is considered (Table 2). In the years when mixed bag limits were in force in this area, a great number of arrests for the possession of protected ducks were made. In addition, others of the "protected" species were discarded in the field. On the other hand, some species sufficiently depleted to be in danger occur so rarely that they are seldom shot. Such is the case of the wood duck, which is seldom seen on this refuge and only one or two have been checked through the station. On the

contrary, the redhead, once under special protection, is sufficiently abundant at Bear River to be found in the bags rather frequently (Table 4). Under present conditions a bag differential favoring redheads would have little, if any, effect. This is shown by the fact that during the 1948 season the redhead comprised only 0.48% of the total bag, and if the season were closed on redheads, it is doubtful that the number killed would be much lower. It follows that mixed bag limits are particularly difficult to enforce and violations would be numerous. Educating the average public hunter to the point where he can identify birds in flight is virtually impossible, and dead birds cannot be revived. Thus, the practice of setting the number of each species which may be taken is of doubtful conservation value. It would be better to set open seasons for times when the species to be protected would not be abundant.

THE THREE-SHELL LAW

The three-shell law is probably of more value in other areas where there is more opportunity to shoot into flocks. The law, enacted in 1935, had little effect on the curve of the graph of Figure 1; however, the main value of the law is considered to be in the reduction of the number of ducks crippled and in reducing hunting pressure. On the other hand, there are occasions when an extra shell would have bagged a cripple which otherwise might have escaped to die later. The law is an added burden to the enforcement officer as well as to the hunter. It is questionable, at least on this area, that additional shells result in more crippled ducks. Single-shot guns also cripple ducks, and here, as in most public areas, there will always be some wild shooting.

In other areas it has been demonstrated that the opportunity to cripple more ducks through the loading of more than three shells is sometimes present, with the result that cripple losses are often high. It must be granted that if flocks of ducks are the targets, the number of cripples is likely to be proportional to the number of shots fired. A good hunter might be able to bag his limit out of a single flock, which is not too objectionable; but a poor hunter could, with additional shells, cripple more than a limit and remain at his stand to wait for another flock. Again regulations are not predicated on the basis that each hunter will bag the limit, but rather a certain portion thereof. If each hunter could participate to the complete extent allowed by the regulations, the regulations would have to be made even more restrictive.

In summary the effect of the regulations in limiting the number of hunters is of utmost importance, for the number of hunters determines the total kill more surely than direct regulation of bag limits. Other factors being considered, an over-all set of regulations will tend to determine the number of hunters who may be expected to participate. Thus, it is the cumulative effect of all the regulations which checks the probability of over-cropping the waterfowl population. It is the administrators' unenviable task to correlate these pressure expectancies with waterfowl population expectancies and to formulate an intelligent and practical set of regulations that will permit maximum hunter participation.

THE RELATION OF KILL TO POPULATION

The total kill and the species composition of the bags are not always in proportion to the total population, but frequently depend on the population density and species distribution on the open area. This is illustrated during the hard freezing weather, when the population is low and the birds are concentrated on potholes and other localized areas. This type of distribution often results in higher bag averages despite the lower total population. The same may be said of individual species. Note that on Table 5 such species as the redhead, canvasback, and lesser snow geese, while fairly abundant, comprise a low percentage of the total bag. This is due more to distribution than to any other factor. The snow geese favor areas not open to hunting, while the deep water ducks are, by their habits, less accessible to hunters, especially hunters on foot. In contrast, the shoveller, which is probably more vulnerable physically and is less wary, prefers the shallow water and vegetated parts of the open area; it is therefore found more commonly in the bags than its position in the total population would suggest. Vulnerability due to botulism has been noted, and it is common that in early seasons some of the weakened birds fall prey to the less discriminating hunters.

The foregoing applies mainly to local areas, and a more comprehensive study of perhaps State-wide scope would probably reveal a closer relationship between total population, species composition, and species kill. For the most part, the comparatively close relationship between percentages of each species present and their percentages in the bags is considered a substantiation of current census methods.

SELECTIVE SHOOTING

Selective shooting, or the singling out of preferred species, is known to have

TABLE 5.—RELATIONSHIP OF AVERAGE TOTAL POPULATION DURING HUNTING SEASONS TO PERCENT OF TOTAL POPULATION AND PERCENT OF TOTAL BAG, ON INDIVIDUAL SPECIES BASIS

Species	1946			1947			1948		
	*Average population during open season	Percent of total pop. during open season	Percent of total bag	*Average population during open season	Percent of total pop. during open season	Percent of total bag	*Average population during open season	Percent of total pop. during open season	Percent of total bag
Mallard	27,000	11.55%	9.20%	19,600	6.32%	10.11%	25,000	8.69%	12.40%
Gadwall	14,000	5.99	6.93	12,000	3.90	7.71	9,000	3.13	4.91
Baldplate	13,000	5.56	3.94	12,900	4.18	2.73	21,000	7.29	3.55
Pintail	72,300	30.92	27.85	105,500	34.21	30.17	86,700	30.14	30.18
G. W. Teal	64,000	27.36	35.50	79,000	25.61	26.58	87,500	30.41	31.42
Cin. Teal	900	.38	.61	1,420	.46	.81	570	.20	.37
Shoveller	16,000	6.84	9.77	42,000	13.61	15.66	38,000	13.21	12.83
Redhead	4,700	2.01	1.17	7,800	2.53	.89	3,400	1.18	.48
Canvasback	9,300	3.98	1.91	17,400	5.64	3.36	5,800	2.02	1.10
Scaup	2,000	.86	.60	3,200	1.04	.27	1,800	.62	.23
Am. Goldeneye	900	.39	.45	700	.23	.45	870	.30	1.23
Bufflehead	800	.34	.07	450	.15	.05	600	.21	.45
Ruddy	350	.15	.62	380	.12	.45	370	.13	.21
Common Can. Goose	700	.30	.64	1,700	.55	.45	980	.34	.35
Lesser Snow Goose	6,500	2.78	.40	4,000	1.30	.17	4,830	1.68	.08
Misc.	1,400	.59	.34	450	.15	.14	1,300	.45	.21
TOTALS	233,850	100.00	100.00	308,420	100.00	100.00	287,720	100.00	100.00

* Average based on three counts made during each hunting season.

influenced the composition of the bags to a limited extent. This practice presupposes an abundance of the preferred species, as well as the skill of the hunter. The majority of hunters usually take what comes to insure a full bag. Again, too many hunters cannot identify birds in flight with sufficient speed to select the more desirable ducks. On the other hand, the mallard's popularity and spectacular plumage probably result in a higher percent of kill than its relative position in the population would warrant (Table 5). This is thought to be partly due to its habits, but also due to selective shooting when a choice is presented. The high frequence of mallards in the bags is in line with its high percentage of banding returns. The shoveller, despite its unpopularity, is also high in percent of kill because of its availability and vulnerability.

BANDING

It is a common practice to help evaluate population figures on the basis of returns on banded birds. Analyses of the banding data assembled at the Bear River Refuge show little obvious correlation with hunting statistics. A sharp reduction in the percentage of returns is shown. An earlier banding program indicated the effectiveness of regulation. Other stations report much higher percentages of first-year banding returns. These variations may be due to differences in location, hunting pressure, migration dates, species banded, etc. The wide difference between the first year returns on the redhead is due to its deep water habits and the fact that resident birds probably leave the area early. Many banding programs include returns from various areas, while the present study lists only those for the Bear River Refuge. The results at Bear River show a wide difference between the percent of first year returns and the percent of the species population killed, and suggest that the resident population is more vulnerable, while birds coming in are more wary and by their numbers cut down the percent of the population killed. In 1947 the number of first year returns for the Refuge was 4.38% of the total banded. Using these results as a basis for determining the percent of kill, it can only be assumed that the 4.38% could represent the percentage of the resident population killed, while the 2% kill based on actual bag records and the estimated population includes, and must be influenced by, migrating birds. Further study might suggest from the foregoing a basis for determining the numbers of birds passing through the area.

SEX AND AGE RATIOS

Table 6 is a tabulation of the sex ratios of ducks checked through the station during the hunting seasons of 1936 to 1940. Methods used for the study assured an accuracy of about 99%.

Table 7 indicates a ratio of 122 males to 100 females which is the reverse of the findings of the earlier study. Additional information on ages is also given. Both projects were carried on in conjunction with the operation of the checking station, while the 1947 work was done in cooperation with the Research Division of the Refuge.

TIME SPENT BY HUNTERS IN THE FIELD

Spot checks to determine the amount of time spent in the field were made for

the years 1933, 1940 and 1948; these years were selected because of their chronological positions and their varied regulations. Table 2 indicates that 1933 had a 60-day season and a 12-duck bag limit, while 1940 and 1948 had 60- and 40-day seasons and 10- and 5-duck bag limits respectively. Since the factors were varied, it would be reasonable to assume that the hunters would be influenced accordingly. On the contrary, it was found that in 1933, with 116 samples checked, a hunter day averaged 7.61 hours; in 1940 an average of 220 samples indicated that a hunter day consisted of 7.73 hours in the field; and in 1948, 234 hunters averaged 7.23 hours per day in the field. Thus, from a generous number of samples (570), it would appear that regardless of various regulations the average hunter at Bear River spends about 7.50 hours in the

TABLE 6.—SEX RATIO OF BIRDS KILLED
BEAR RIVER MIGRATORY BIRD REFUGE, UTAH
HUNTING SEASONS 1936 TO 1940

Species	1936 Nov. 1-Nov. 30		1937 Nov. 1-Nov. 30		1938 Oct. 15-Nov. 28		1939 Oct. 22-Dec. 5		1940 Oct. 16-Dec. 14		Five-year period	
	Total	M : F	Total	M : F	Total	M : F	Total	M : F	Total	M : F	Total	M : F
Pintail	2106	40 : 60	2873	43 : 57	4012	38 : 62	3477	33 : 67	4023	35 : 65	16491	38 : 62
Mallard	854	48 : 52	1519	56 : 44	2483	53 : 47	1673	49 : 51	3017	53 : 47	9546	52 : 48
Baldplate	150	44 : 56	360	58 : 42	441	41 : 59	604	35 : 65	1263	39 : 61	2818	43 : 57
Goldeneye	48	14 : 86	80	20 : 80	64	22 : 78	28	25 : 75	105	18 : 82	325	58 : 42
Gadwall	302	48 : 52	750	51 : 49	785	44 : 56	1133	48 : 52	565	51 : 49	3535	48 : 52
Shoveller	733	52 : 48	692	45 : 55	1541	53 : 47	1367	43 : 57	2111	54 : 46	6444	49 : 51
Cin. Teal	57	51 : 49	38	40 : 60	171	26 : 74	66	50 : 50	19	31 : 69	351	40 : 60
G. W. Teal	1082	59 : 41	1343	53 : 47	2689	54 : 46	2748	60 : 40	3628	59 : 41	11490	57 : 43
Scaup	59	50 : 50			110	45 : 55	26	60 : 40	84	48 : 52	279	50 : 50
Redhead	12	50 : 50			472	48 : 52	75	61 : 39	258	46 : 54	817	51 : 49
Canvasback	33	33 : 67			444	50 : 50	101	53 : 47	379	52 : 48	957	47 : 53
Ruddy					55	36 : 64	10	10 : 90	13	16 : 84	78	21 : 83
Bufflehead					121	26 : 74	75	28 : 72	159	25 : 75	355	26 : 74
TOTALS	5436		7655		13388		11383		15624		53486	44 : 56
Sex ratio all species		48 : 52		46 : 54		47 : 53		45 : 55		48 : 52		44 : 56

TABLE 7.—ADULT-JUVENILE RATIOS OF BIRDS TAKEN ON BEAR RIVER MIGRATORY BIRD REFUGE, HUNTING SEASON—1947.
Adult : Juvenile—1 : 0.6775
Male : Female —1 : 0.8219

Species	Adult Male	Juvenile Male	Adult Female	Juvenile Female	Total Adult	Total Juvenile	Total Adult & Juvenile
Pintail	980	204	934	414	1,914	618	2,532
Mallard	383	83	235	140	618	223	841
Baldpate	65	61	35	71	100	132	232
Gadwall	230	113	130	161	360	274	634
Shoveller	295	497	119	427	414	924	1,338
Green-winged Teal	1,020	398	386	430	1,406	828	2,234
Canvasback	42	101	35	107	77	208	285
Redhead	14	30	14	13	28	43	71
Cinnamon Teal	10	18	7	19	17	37	54
Golden-eye	2	10	10	14	12	24	36
Bufflehead	2	3	8	23	10	26	36
Ruddy	—	1	1	2	1	3	4
Lesser Scaup	2	2	—	18	2	20	22
TOTALS	3,045	1,521	1,914	1,839	4,959	3,360	8,319

field. The figures reveal that hunters spend about 2.2 hours per duck bagged. These are at least interesting side lights as to how much time is consumed in hunting.

	1933	1940	1948
Bag Limit.....	12	10	5
Days in Season....	60	60	40
Number of Samples	116	220	234
Av. hours per hunter day.....	7.61	7.73	7.23
Average daily bag.	3.22	3.377	2.29
Av. hrs. per duck bagged.....	2.36	2.29	3.16

SUMMARY

1. The Bear River Migratory Bird Refuge, situated in the northern part of Utah, contains 64,000 acres, including approximately 12,000 acres which are open to public hunting on a strictly regulated basis.

2. Operation of the checking station since 1932 has resulted in voluminous and detailed data. The census figures cited are the result of careful estimations. All other figures are based on actual records as they were made at the times noted.

3. The most common type of hunting is that from blinds in or near the water. The quality of the hunting is comparable to that of private clubs.

4. Laws on differential bag limits are difficult to enforce and are not always effective for the purpose intended, mainly because of the inability of hunters to identify birds in flight. Setting the hunting dates to miss the presence of species to be protected would probably be the more effective conservation measure.

5. Bag limits affect bag averages little when limits are set above a certain point; however, they do affect the total kill. In certain situations it would be desirable that the bag limit be increased and that the length of the season be shortened.

6. The value of the three-shell law as applied to this area has been questioned, but it has over-all value, mainly in limiting the number of cripples and in reducing hunting pressure.

7. The bag averages are in relation to population density rather than to total population; thus distribution of the birds is a determining factor in the average number of birds bagged. In other words, the bag average does not decrease greatly as the season progresses, but the reduction in kill is due to the decrease in the number of hunters. The number of hunter-days spent in the field is the most important factor in determining the total kill.

8. In general, the ratio of individual species killed to the total bag is in proportion to the ratio of species present to the total population. Principal deviations are those species which avoid the open areas and those which are particularly vulnerable, such as the shoveller.

9. The split season and the State optional open-season dates are objectionable in that the movement of hunters from one State to another permits longer seasons, and the enforcement problems are increased.

10. Standard starting and closing times of around 7 a.m. to 4 p.m. would be less confusing than the present sunrise and sunset schedules. Daily time limits influence the total kill less than they affect the habits of the ducks.

11. For the years 1946–48 the total bag was just under 2% of the average total population during the season. This does not take into consideration the

numbers of birds passing through the Refuge.

12. The most popular days are openings, holidays, and week ends. During the 1948 season these days accounted for 74% of the total hunter days. Sundays alone comprised 37%. On the days when the pheasant or deer seasons open during the duck seasons there are abrupt drops in the number of hunters on the Refuge. The number of hunters also drops as the severity of the weather increases. Restrictive regulations also affect the number of hunters.

13. Except for the opening day, the bag averages are reduced as the number of hunters increases.

14. The average bag for the years 1932–48 was 3.5 birds per hunter day. For the years 1933, 1940 and 1948 the average hunter day on the Refuge amounted to 7.52 hours. In 1948 the average time per duck bagged was 3.16 hours.

15. Hunter success is usually proportional to the population density, hunting skill, and the quality of equipment.

16. Green-winged teal and pintails are the two most abundant ducks of the Refuge population and the total bag.

17. The sex ratio based on 53,000 ducks checked in 1936 to 1940 was 79 males to 100 females. In 1947 the ratio was 122 males to 100 females.

18. While the effectiveness of restrictive hunting regulations is less than their outside limits would make them appear, they remain as important instruments for the conservation of waterfowl. The regulations provide a framework to allow maximum waterfowl hunting while at the same time preserving sufficient stock to insure future hunting.

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EFFECTS OF TOXAPHENE AND CHLORDANE ON CERTAIN GAME BIRDS[1]

George Post

An infestation of grasshoppers began building up in Wyoming in 1946, and by 1948 there was need for control measures. Two insecticides, Toxaphene and Chlordane, were available for field control of these insects. A preliminary 50,000-acre experimental control plot was set up by the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in 1948 to determine the best means of disseminating these insecticides for the proposed control program for 1949 and 1950. Results of this experimental work showed that Toxaphene or Chlordane on large flake bran should give the best grasshopper control.

The bran bait was mixed at the rate of one pound of Toxaphene or one-half pound of Chlordane per one hundred pounds of bran. During 1949 this bait was used at the rate of five pounds per acre and in 1950 at the rate of ten pounds per acre. During both summers, many areas were baited and rebaited until some received as much as a total of thirty-five pounds of bait per acre. All baiting was done from aircraft.

The grasshopper control measures covered 1,765,708 acres in 1949 and

[1] Contribution from Federal Aid in Wildlife Restoration Act Project 28-R, Wyoming.

2,440,000 acres in 1950 according to the Bureau of Entomology and Plant Quarantine (1950). The use of these two toxic substances over large areas caused concern to the game management personnel and entomologists of Wyoming as to the effects on birds. The large acreage covered both years made it impossible to observe a representative acreage for effects on wildlife with the available personnel. A total of 1,200 acres of baited land and 200 acres of non-baited land were studied. The same amount of time and effort was expended per acre on the control plots as on the baited plots.

Six 100-acre plots in the baited areas were covered once each week during the summer of 1949. These plots were searched once each month during the fall and winter of 1949–1950. Control plots were not established during this period due to a shortage of personnel. During the summer of 1950, ten baited plots and three control plots of 50–70 acres each were covered at least twice each week. These plots were located in Johnson and Sheridan Counties in 1949 and 1950. The amount of bait applied on these plots ranged from 5 to 35 pounds per acre, depending upon the regular baiting and rebaiting operations. Plots were chosen which were thought to include typical habitat of the game birds in the area. Within one or more of these plots were to be found sage grouse, sharp-tailed grouse, pheasant, Hungarian partridge, Chukar partridge, Gambel's quail and ducks. There were also many species of song birds and predatory birds. Skunks, badgers and many species of rodents were to be found, as well as reptiles and fish.

Prior to the baiting operations in the field, acute toxicity experiments were carried out with both insecticides on pheasants, Chukar partridges and sage grouse.

Thirty ring-necked pheasants, equally divided as to sexes, and averaging 1.8 ± kilograms in weight were given dosages of 0.1098 to 5.6800 grams of Toxaphene. The mg/kg equivalent of this dosage ranged from 90 to 5000. Birds receiving the highest dosages died in two to four hours. Two birds receiving 200 mg/kg died in approximately twenty days. Two birds receiving 100 mg/kg survived. It can be assumed, therefore, that the acute dosage is 200 mg/kg and the critical dosage is between 100 and 200 mg/kg.

Twenty-one ring necked pheasants, equally divided as to sexes, and averaging 1.5 ± kilograms in weight were given dosages of 0.182 to 5.150 grams of Chlordane. The mg/kg equivalent of this dosage ranged from 100 to 5,000. Birds receiving the higher doses died in 10 to 56 days. One bird responded acutely at the 500 mg/kg level, in 17 days, and the other continued alive. Those receiving more than 500 mg/kg all responded acutely. One bird of two responded acutely at the 400 mg/kg level in 50 days. One bird of the two receiving 300 mg/kg responded acutely in 58 days. One bird of two receiving 200 mg/kg responded acutely in 55 days. Those receiving 100 mg/kg remained alive. It can be assumed, therefore, that the critical dosage is near the 500 mg/kg level.

Sixteen Chukar partridges, equally divided as to sexes and averaging 0.55 ± kilograms in weight were given dosages of 0.0068 to 0.0459 grams of Toxaphene. The mg/kg equivalent of this dosage

ranged from 10 to 90. All but one of the birds receiving more than 60 mg/kg of Toxaphane died in two and one-half hours or less; one bird receiving 70 mg/kg died in five days. One bird responded acutely to the toxicant at the 50 mg/kg level and died in one and one-half hours, whereas a second survived. It can be assumed, therefore that the critical dosage is near the 50 mg/kg level.

Twelve Chukar partridges, equally divided as to sexes, and averaging 0.52 ± kilograms in weight were given dosages of 0.051 to 0.513 grams of Chlordane. The mg/kg equivalent of this dosage ranged from 100 to 900. Duplicate Chukar partridges were not used in this experiment due to a shortage of birds. The birds receiving 200 or more mg/kg responded acutely from two to seventy-six hours after receiving the toxicant. The bird receiving 100 mg/kg survived. It can be assumed, therefore, that the acute dosage is near the 200 mg/kg level and the critical dosage is between the 100 and 200 mg/kg level.

Eleven sage grouse were given Toxaphene and four sage grouse were given Chlordane. Results were inconclusive. The sage grouse is an extremely fragile bird with which to attempt this type of experiment. Under ideal conditions, they will survive up to seven or eight days in captivity. The experimental birds given Toxaphene and Chlordane died in seventy hours or less. The control birds died in eighty hours.

A method for diagnosis of Toxaphene or Chlordane poisoning was developed from the symptomatology, gross pathology, and histopathology of the birds experimentally killed. Both insecticides cause a general toxemia which is not often found under field conditions. The diagnosis is not entirely specific, but toxemias are quite rare in nature in Wyoming.

It was not possible to distinguish Toxaphene poisoning from Chlordane poisoning because both compounds appeared to have nearly the same biological action. In order to utilize this method of diagnosis, dead material had to be located before post-mortem autolysis was advanced. Birds found dead but deteriorated were listed as such.

FINDINGS

The average number of game birds seen each day by all personnel and all dead or affected birds were tabulated (Table 1). During the entire observation period, six sage grouse, one mallard duck, one meadowlark and one prairie horned lark were found ill in the baited areas. Symptomatology, gross pathology and histopathology in all these birds showed the same general toxemia noted in known insecticide poisoning. Most of the birds showed such advanced conditions that it is a certainty that the effects would have been fatal.

One sage grouse and one meadowlark were found dead in the baited areas. The cause of death was diagnosed as general toxemia similar to insecticide poisoning.

Three sage grouse, two pheasants and one sharp-tailed grouse were killed by automobiles in or near the baited plots. These birds all showed a general toxemia similar to insecticide poisoning. Some showed enough pathology to assume that the effects would have been fatal.

One sage grouse was killed by a mowing machine in an alfalfa field on a searched plot. This bird showed exten-

TABLE 1.—SUMMARY OF GAME BIRD LOSSES ON STUDY AREAS

	Sage Grouse		Pheasants		Sharp-Tailed Grouse		Hungarian Partridge		Totals	
BAITED PLOTS:	No.	%	No.	%	No.	%	No.	%	No.	%
Average Number Birds Seen Each Day.....	213		48		12		31		304	
Birds Found Dead....	45	21.1	22	45.8	3	25.0	1	3.2	71	23.4
Suspected Insecticide Poisoning.....	11	5.1	2	4.2	1	8.3	0	0.0	14	4.6
Dead but Deteriorated	20	9.4	7	14.6	0	0.0	1	3.2	28	9.2
Partially Eaten.....	2	0.9	13	27.1	2	16.6	0	0.0	17	5.6
Dead from other Causes	12	5.6	0	0.0	0	0.0	0	0.0	12	3.9
UNBAITED (CHECK) PLOTS:										
Average Number Birds Seen Each Day.....	40		19		0		10		69	
Birds Found Dead....	0	0.0	7	36.8	0	0.0	0	0.0	7	10.1
Partially Eaten.....	0	0.0	6	31.6	0	0.0	0	0.0	6	8.7
Dead from other Causes	0	0.0	1	5.3	0	0.0	0	0.0	1	1.5

sive gross pathology and histopathology of a general toxemia similar to insecticide poisoning. The effects would surely have been fatal. In addition to the above birds, 118 were found dead on the baited plots, including seventy-one game birds (Table 1). Twenty-seven of the game birds were deteriorated, thirty-one were partially eaten by predators, and twelve were dead from other causes including automobile casualties, drowning, illegally kills and mowing machine casualties. One mallard duck was found ill but was released because symptoms did not warrant sacrifice. Forty-seven song birds and predatory birds were also found dead or ill in the baited plots. There were eleven meadowlarks, seven prairie horned larks, five blackbirds, six lark buntings, one kill-deer, and one kingfisher found dead but deteriorated. Four lark buntings were found ill but were released, as their symptoms did not justify sacrifice. Seven magpies, two crows, two sparrow hawks, and one marsh hawk were found dead but deteriorated.

One muskrat, three skunks, and one field mouse were found dead on the searched plots in the baited area, but were deteriorated. Many suckers and bullheads were found dead or affected in Crazy Woman Creek after baiting. These fish were probably killed or affected by insecticides.

The mortality of four species of game birds on the baited plots are given as percentages of the average number of birds seen each day (Table 1). The number of pheasants found partially eaten by predators was high, but not significantly higher than the percentage showing pathology indicative of insecticide poisoning. The dead but deteriorated birds show the largest mortality of these four species. The cause of death is unknown. Possibly many of these birds, as well as some of those partially eaten by predators were actually killed by insecticides but definite proof is lacking. The total observed game bird mortality from all conditions on the baited plots was 23.4 per cent, as compared with 10.1 per cent on the control plots (Table 1). This is considered normal. There were six pheasants found dead and partially eaten by predators in the control plots. This accounted for

31.6 per cent mortality in the pheasant population. One pheasant found dead was diagnosed as having died from an intestinal obstruction. One flicker was found dead but was deteriorated. Twelve hundred acres of baited land and two hundred acres of unbaited land were searched. The game bird population per acre on both baited plots and control plots were reasonably comparable. It is apparent that part of the increased total mortality on the baited plots is due to the effects of Toxaphene or Chlordane used for grasshopper control.

Two sharp-tailed grouse were taken with a shotgun after having been hatched and raised in a baited area. Neither of these birds showed pathology due to insecticide poisoning.

Twelve sets of pheasant viscera were collected during the hunting season from the baited plots. One showed extensive pathology of a general toxemia similar to insecticide poisoning. The remaining eleven showed no pathology.

The observations carried out once each month during the winter of 1949–50 yielded no dead birds which could be attributed to the effects of insecticides. The only excessive winter kill noted was in the Gambel's quail. This species almost completely died out on the one plot where they were observed.

DISCUSSION

It was not possible to cover a representative portion of the treated areas, so it was deemed far better to search thoroughly a smaller portion than to search a larger acreage in a random manner. Random searching may have netted some dead or affected wildlife, but more complete data could be gathered by controlled searching. It is extremely hard to find all dead animals on the plots. Most birds are well camouflaged and they have a habit of getting under the heaviest cover to die.

The method of diagnosis used for this work is considered to be quite accurate. The effects of both insecticides appear to be a general toxemia. There are very few materials in nature which will give symptoms and pathology of a toxemia. The personnel of the Wildlife Disease Research Laboratory in Wyoming state that no game animals or birds have shown this pathology or even similar pathology in the three years they have been observing wildlife diseases. Therefore, this method is of use with limitations. These limitations were given consideration in each diagnosis.

In 1949, it was noted that most of the dead birds were found within a period of three weeks. This three-week period began about fifteen days after the initial baiting. During 1950, baitings and rebaitings were carried out in such a manner that it was not possible to gather data of this type.

Man is continually fighting insects. Now that he has compounds available which will control them over large areas, control measures will no doubt become more extensive and more common. The effects of insecticides, fungicides, herbicides, and such compounds on wildlife will be a great problem in wildlife management. These compounds should be used with caution until data are collected in an attempt to determine their effects on wildlife. Generally speaking, compounds which are toxic to one animal will be more or less toxic to others. The unfortunate thing is that wildlife is in a vulnerable position when-

ever toxic substances are used in large operations for insect control.

SUMMARY

A total of 4,205,708 acres of range land of Wyoming was treated with Toxaphene and Chlordane bran bait for grasshopper control during 1949 and 1950. Effects of this baiting operation on wildlife were observed on 1,200 acres of baited land. Two hundred acres of unbaited land were observed as a control.

Eighteen dead and ill birds which were found on baited plots proved to be affected by insecticide poisoning. One hundred and twenty-two other birds were found dead or affected in baited plots, but the cause of death or illness could not be proved. One muskrat, three skunks, and one field mouse were found dead in the baited plots, but were deteriorated. Eight dead birds were found in the control (unbaited) plots.

The total game bird mortality in baited plots was 23.4 per cent while it amounted to only 10.1 per cent in control plots. Per cent mortalities of song birds and predatory birds were not determined.

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IDENTIFICATION OF WATERFOWL NEST PREDATORS *

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The Maine Cooperative Wildlife Research Unit has been carrying on an intensive investigation of duck nesting habits for a number of years. Nests of waterfowl, of which the ring-necked duck (*Aythya collaris*) and the black duck (*Anas rubripes*) are of most importance in the State, are searched out each season by members of the Unit staff. Quite frequently nests under observation have been destroyed by predators that remained unindentified.

The objective of the present study, which was made in 1949, was to learn as much as possible about typical signs that may be left at a plundered nest by a predator so that the latter may be identified. Predator pressure on nesting waterfowl was not considered. The writer wishes to express his deep appreciation to Howard L. Mendall, Leader of the Maine Cooperative Wildlife Research Unit, for suggesting this problem, and for much assistance in the field work, and in the preparation of the manuscript. Malcolm W. Coulter and Frank T. Haseltine, Assistant Leader and former Graduate Assistant, respectively, of the Maine Unit, were

* A contribution from the Maine Cooperative Wildlife Research Unit—Maine Department of Inland Fisheries and Game, University of Maine, Wildlife Management Institute, and U. S. Fish and Wildlife Service, cooperating.

also very helpful and contributed many field data. Benjamin R. Speicher, head of the Department of Zoology at the University of Maine, allowed the author the use of departmental equipment in the laboratory phase of the problem. Charles C. Sperry, Biologist, of the U. S. Fish and Wildlife Service Laboratory at Denver, Colorado, deserves special thanks for identifying the many samples of mammal hairs submitted to him.

The majority of the destroyed nests studied were in the vicinity of the Moosehorn National Wildlife Refuge, near Calais, in eastern Maine. Other areas where data were gathered include the Davis-Holbrook marsh, located in East Eddington in Penobscot County, and Goose River in Waldo County.

The value of knowing which predators are exerting pressure on waterfowl nests is apparent. Predator control on a regional or statewide basis is not ordinarily considered to be a practical game management procedure, but in localized areas, such as in waterfowl nesting concentrations, or on refuges, control of harmful predators may be advisable. This has been clearly pointed out by Kalmbach (1938).

REVIEW OF LITERATURE

A search of available literature has disclosed that little has been published in North America with regard to identification of predator sign on nests of game birds.

Sowls (1948), in studying the Franklin ground squirrel and its relation to nesting ducks, described some characteristic types of egg shell remains left by several predators. Sooter (1946) gave information on the habits of the coyote in destroying nests and eggs of waterfowl. Stoddard (1932) reported on characteristic signs left by some predators of bobwhite quail nests. Nelson and Handley (1938) studied methods used by gray foxes in raiding bobwhite quail nests. Darrow (1938) observed the evidence left by captive predators after destroying ruffed grouse eggs, and later in *The Ruffed Grouse*, by Bump, Darrow, Edminster and Crissey, (1947), included data on identification of predators in destroying grouse nests. Stanton (1944) studied methods used by the Douglas ground squirrel in Oregon in destroying "dummy" nests of the ring-necked pheasant and bobwhite quail.

Use of artificial nests or other artificial conditions.—Sowls (1948) placed eggs at skunk dens and later checked the results. Sooter (1946) fed chicken eggs to penned coyotes to determine their method of handling the eggs and the exact condition in which the shell remnants would be left. Nelson and Handley (1938) studied the techniques of gray foxes in destroying natural, but transplanted, bobwhite quail nests; the mammals were attracted through the placing of fresh fox scats at the nests. Darrow (1938) fed ruffed grouse eggs to various penned predators to determine methods used by those animals in eating eggs; and Stanton (1944) used "dummy" ring-necked pheasant and bobwhite quail nests to learn the habits of the Douglas ground squirrel in depredations on the nests of those species. Stoddard (1932) used penned animals to determine the characteristic appearance of bobwhite quail egg shells left by various predators.

METHODS OF STUDY

Natural Nests

During the course of the 1949 waterfowl nesting studies, conducted by Unit personnel, 28 duck nests were either found destroyed when first located, or were found destroyed on subsequent checks. The species and number of nest depredations occurring are as follows: ring-neck duck—16; black duck—11; American goldeneye—1.

Artificial Nests

When the study was first organized it was thought that the number of natural nests destroyed by predators would be rather limited. Therefore, artificial nests were used to supplement other data. A total of 34 such nests was constructed, of which 26 were ultimately destroyed by predators. Eight brown, medium-sized hen's eggs were used in each artificial nest. The color and shape of these eggs resembled those of both the ring-necked duck and black duck more closely than any other readily available eggs. Down and feathers previously plucked from dead black ducks was mixed with available vegetative material in the construction of the "dummy" nests. Usually the vegetation consisted of dried grass, leaves, or twigs—about the same materials that a duck uses in constructing a nest. An attempt was made to simulate a natural nest in shape, size, construction, materials, and placing of eggs.

When an artificial nest was first established, the eggs were covered, as by a female duck, with part of the nest material. If the nest remained undisturbed for a week, the concealing material was then removed and the bare eggs left exposed to further invite predation.

Since the primary objective of the study was to identify predators by the sign left at destroyed nests, the artificial nests could be placed in areas where the probability of destruction by a specific predator was great. Thus if skunk damage was desired, a nest could be situated near a known skunk den, or in typical skunk habitat. If raccoon damage was desired, a nest site near water was chosen.

Advantages in the Use of Artificial Nests

The most important advantages that accrue from the use of artificial nests are: (1) the number of nests that may be studied can be controlled; (2) specific predators can be enticed to destroy a nest; (3) the investigator has control over the nest and nest site before destruction takes place (for example, an area near the nest may be cleared and smoothed so tracks will show, or a light stick barrier can be placed around the nest to increase the chances for catching hairs, to be used for identification).

APPEARANCE OF SUCCESSFULLY HATCHED EGGS

Girard (1939) has given an excellent description of the appearance of successfully hatched shoveller eggs, which fits closely with the observations of the present study. Girard states that after exposure to weather the shell lining of an egg that was broken prior to natural hatching remains tightly attached to the shell; whereas the lining of successfully hatched eggs readily separate from the shell. Sowls (1948) presents an excellent photograph of a successfully hatched egg.

DIAGNOSTIC SIGNS LEFT BY INDIVIDUAL SPECIES

Raccoon

Twenty of the nests studied were destroyed by raccoon. Sixteen of them had been pawed, nine extensively so; that is, the base of the nest had been disturbed, or the nest rim had been pulled out or broken in several places. Seven had the rim pulled out only on one side. Three nests had not been disturbed at all, except for the removal of the eggs. The one remaining nest was that of an American goldeneye in a tree cavity which the raccoon could not enter, but withdrew the eggs with its forepaws. Thus 80 per cent of the nests destroyed by raccoon were found to be pawed to some extent. This differs from the findings of Bump et al (1947) who observed, with respect to grouse nests destroyed by raccoon, that they were "intact or very slightly disturbed."

Presence of egg shells at destroyed nests.—In all twenty examples of nest destruction by raccoon, egg shells were found somewhere within thirty feet (most were within six feet) of the nest.

Appearance of egg shells.—Shell remains left by a raccoon are typically half shells, either eaten from the end of the egg, or less frequently, from the side, causing a lengthwise splitting or breaking of the egg. The shells are coarsely fractured, and do not have a finely chewed appearance. In some instances the shells are completely broken (in contrast to crushing), with small pieces perhaps the size of a fifty cent piece left. Small indentations caused by the teeth of the animal are seldom apparent on eggs destroyed by raccoon.

Raccoon typically do not consume the egg shell with its contents, but rather leave most of it at the spot where the egg is consumed.

Bump et al (1947) reported that ruffed grouse egg shells * left by raccoon usually retain much of their spherical shape, with one end bitten off, most frequently the small one; and further, if broken to a greater extent the fragments are neither held together by membrane nor mixed with debris.

Hair found at nests destroyed by raccoon.—In 19 of the 20 nests destroyed by raccoon, hairs sufficient for identification of that mammal were found.

Nest sites most susceptible to raccoon destruction.—Raccoon damage occurred in both wet marsh areas and dry upland sites. The raccoon's fondness for water often leads it to nests that are ordinarily out of reach of the fox; its ability to climb trees makes it a potential menace to hole-nesting ducks.

Characteristics peculiar to the raccoon.—When destroying a nest located in dry cover near water, a raccoon will frequently carry the eggs near the water to eat, at times leaving shells in shallow water. Another habit (among larger mammals at least) that appears to be peculiar to the raccoon is that of carrying the eggs to a prominent rock or boulder near the nest and there eating the eggs. Large boulders at the edge of a stream or lake are particularly favored by the animal for this practice. In destroying nests located in a wet marsh, however, the animal usually consumes the eggs at the nest site.

In one instance a raccoon raided an

* It is recognized that eggs of duck and ruffed grouse differ greatly in size and thickness of shell; nevertheless, descriptions of destroyed shells of each are somewhat similar.

artificial nest and ate only four of the eight eggs present. Either the same animal or another raccoon returned to the nest nine days later and consumed the remaining four eggs.

Mink

Four of the natural nests (one black duck and three ring-necked duck) under observation were found to have been destroyed by mink.

Condition of the nest structure.—Ordinarily a mink does not molest the structure of a nest. Three of the four nests observed were undisturbed, while the fourth was deranged merely to the extent of a hole being dug into it from beneath—it apparently was situated immediately over a mink burrow. These limited observations are substantiated by additional data in the files of the Maine Unit.

Bump et al (1947) stated that the nest structure was not disturbed in the case of mink predation on ruffed grouse nests.

Presence of egg shells at destroyed nests.—Egg shells were found at three of the four nests destroyed by mink.

Bump et al (1947) characterized mink damage by stating that shell remains are left at from 1 to 75 feet from the nest in the case of ruffed grouse.

In the three instances where shells were found in the present study, they were actually within the nest or within a few feet of it.

Appearance of egg shells.—Of the three samples of egg shells found, two had rather small holes eaten out of the ends or sides. In the third example the shell was broken into rather small pieces. In all three instances, the edges of the shells were finely chewed.

Bump et al (1947) described the effect of mink (and weasel) on ruffed grouse eggs as, "shell not retaining shape, one half or more usually eaten away along the long axis; edge of remaining portion very finely chewed but the fragments largely held together by the membrane."

Close inspection of the shell remains frequently will disclose tiny tooth marks on unbroken portions of the shell. Although this is not infrequently noted in instances of egg destruction by other mammals, it appears to be particularly true of mink; it has been observed frequently in previous years by personnel of the Maine Unit. The size and spacing of paired tooth marks on an egg shell often helps to establish the identity of a predator. A collection of mammal skulls for comparison with spacing of teeth is of help in such instances.

Hair found at nests destroyed by mink.—Hair was found at three of the four nests destroyed by mink. At the fourth nest the evidence was so conclusive against the mink that a search for hairs was not made.

Nest sites most susceptible to mink destruction.—The four samples of mink depredations on nests during the study were all in aquatic habitat—two at the marshy edge of a lake, one well out into a 70-acre semi-floating marsh, and the other on a floating island surrounded by open water fifty yards from dry land.

Characteristics peculiar to the mink.—Tooth marks found on unbroken portions of egg shells are one of the most helpful identifying signs left by mink. Also mink runways frequently are found quite close to destroyed nests.

Skunk

Condition of the nest structure.—From

descriptions in the literature and from the very limited observations of the present study it appears that a skunk typically tears a nest almost entirely apart. Of the two nests destroyed by this animal in the present study, both were completely demolished. In each case a layering effect was noted of shells and nest material, as if the animal had eaten an egg, dropped the shells, and pawed nest debris over them before eating another egg. In one instance the animal had actually dug into dry ground beneath the nest.

Darrow (1938) in referring to ruffed grouse nests stated, "the skunk invariably crushes the shells completely and in addition tears apart the structure of the nest, mixing the remains with leaf fragments and humus."

Presence of egg shells at destroyed nests.—Egg shells were found at both of the nests destroyed by skunk. In each case they were found mixed with the nest material.

Sowls (1948) stated that the skunk does not carry eggs off. Stoddard (1932) in writing of bobwhite quail nest damage by skunk said that the shells were left near the nest, and Bump et al (1947) came to the same conclusion in studying skunk destruction of ruffed grouse nests.

Appearance of egg shells.—Eggs destroyed by skunk are usually rather easily distinguished from those destroyed by other mammals. A complete chewing of the shells appears to be most common—but the shell fragments are not separated, that is, the egg apparently is crushed in the animal's mouth and the contents then sucked or lapped up—thus the membrane and shell fragments more or less cling together in a shapeless mass. This "crushing" effect is noticeably different from the "chewing" of mink or raccoon.

Sowls (1948) stated that the skunk breaks duck egg shells with its teeth, using the paws and tongue to enlarge the opening; usually breaking more than half the shell and crushing it, thus doing a "messy" job and spilling the contents on the shell or the nest. Stoddard (1932) said that the skunk bites off the top of bobwhite quail eggs and licks out the contents at its leisure. Bump et al (1947) stated that ruffed grouse egg shells are completely crushed by the skunk.

Thus, although only two nests were observed in the present study, findings of all observers agree on the behavior pattern of skunk in destroying nests.

Hair found at nests destroyed by skunk.—Skunk hair was found at the site of both nests destroyed by that animal. In each instance long white guard hairs were located as well as the shorter, underfur fibers.

Nest sites most susceptible to skunk destruction.—Both of the nests destroyed by skunk in the present study were in a dry, upland site.

Characteristics peculiar to the skunk.—The crushing of the egg shells and the destruction of the nest appear to be very characteristic. Odor of skunk was detected at both of the nests, which, although faint, was distinct.

Red Fox

Eight of the nests under observation were destroyed by red fox. Four of these were natural black duck nests and the remainder were artificial nests.

Condition of the nest structure.—In three cases of fox predation the nest rim was pulled out only on one side. In two cases the nest was badly torn up,

the base dug into, and the nest form completely destroyed. The structure of three of the nests was undisturbed. Ordinarily the fox does not dig up a nest as much as either the skunk or raccoon; as a rule, the animal appears to paw out one side, presumably to obtain the eggs more easily.

Bump et al (1947) found that both the red and gray fox usually take the eggs and do not disturb the nest of a ruffed grouse.

Presence of egg shells at destroyed nests.—Egg shells were found at only one nest destroyed by fox. It appears to be a rather common trait of this animal either to eat the eggs, shell and all, or to carry them well away from the nest (often to young in the den) before consuming them.

Darrow (1938) in describing the characteristic fox method of destroying a ruffed grouse nest stated that, "Foxes habitually carry each egg to a point from 1 foot to 75 feet or more from the nest before eating it, each egg usually being taken to a different spot."

Appearance of egg shells.—One sample is not enough upon which to base a description of fox destruction to eggs. However, the egg shells in the one case found, were well broken up and had lost most of the spherical shape. They appeared broken—not crushed—more like damage caused by raccoon than any other for the mammals studied. Additional data in the files of the Maine Unit, substantiate this further.

Hair found at nests destroyed by fox.—Fox hairs were found in each instance of suspected predation by that animal. The underfur is easily caught by twigs and even by herbaceous vegetation, thereby making it readily found at the site of a destroyed nest.

Nest sites most susceptible to fox destruction.—Each of the nests destroyed by fox was either in a dry, upland site or else in a semi-dry marsh—none was in a wet marsh.

Characteristics peculiar to the fox.—A fox may raid a nest and not take all of the eggs present. In one instance, that of a natural black duck nest, one egg was completely ignored and left in the nest. In this connection, Bump et al (1947) stated, "Foxes frequently filch a few eggs at a time from a nest." This is also borne out by file data of the Maine Unit in connection with black duck losses.

Crow

Seven nests were destroyed by crow. Six of these were artificial, and one that of a black duck. Apparently all types of nest sites are susceptible to crow predation.

Condition of the nest structure.—Three of the nests were undisturbed insofar as the cavity was concerned. The black duck nest, which was in thick vegetation, had one side of the rim pulled out and scattered for a distance of three feet. The three remaining artificial nests had the rim lightly pulled out on one side in each instance.

Presence of egg shells at destroyed nests.—Parts of egg shells were found at every nest destroyed by crows. It is seldom that the remains of all eggs can be accounted for at a nest destroyed by this predator. The birds frequently fly to one or more perches to eat eggs, and it appears that, as often as not, more than one crow is involved in the raiding of a nest. However, it seems practically

impossible for a crow to puncture an egg shell and pick it up without leaving some shell fragments, however small, in the nest.

In two instances of the seven, small fragments (half the size of a dime) were found in the immediate vicinity of the nest. In the other five instances the shells recovered were much larger and had retained their spherical character.

Bump et al (1947) characterized crows as leaving grouse egg shells at distances of from 1 to 75 feet from the nest. Sowls (1948) reported that crows sometimes carry duck eggs away from the nest, leaving little evidence; usually when the eggs are carried off, one may expect to see remains of one or more eggs near the nest.

Appearance of egg shells.—Eggs destroyed by a crow are, as a rule, readily attributed to that predator.* Usually the egg retains its spherical shape and has a moderate or large opening, most often on the side. Often there is another smaller puncture just below and to one side of the large opening, caused by the lower mandible of the bird. At times a puncture, with outward projecting fragments, is present opposite the main opening in the shell.

Sowls (1948) reported that a crow breaks the shell with its bill, usually breaking half or less of the shell, never crushing it. In eating the contents the crow does a clean job. The opening is clean-cut, and the broken shell and membrane seldom curl inward. Also, he stated, the crow frequently but not always, makes a small sharp perforation with the lower mandible to one side of the main opening. There may be several such bill marks.

Bump et al (1947) in describing grouse eggs destroyed by crow said, "shell usually retaining its general spherical form . . . irregularly opened at one side; frequently found on stumps. Punctures usually conforming to shape of crow's bill, frequently with smaller outward punctures opposite."

At times a crow will almost completely demolish an egg, leaving small, flat, shell fragments, perhaps the size of a quarter. It is likely that the stage of development of the embryo within the egg is a factor in determining the size of the opening.

Weasel and Unknown Predators

Weasel.—One artificial nest was believed to have been destroyed by a weasel. No shell fragments could be found in or around the nest, which was situated under a lone alder in a low swale of a newly mowed hayfield, making a complete search possible of the immediate vicinity of the nest.

The structure of the nest was not disturbed in the least. A musky odor resembling that of weasel or mink was detected nearby. One reddish brown hair about an inch long believed to be that of a weasel was found, but unfortunately it was lost before identification could be made. Three scats were found within one foot of the nest and were believed to be those of weasel.

* Based on previous studies of the Maine Unit, crows are the chief avian predator on inland duck breeding areas in Maine, and as far as can be determined all avian nest destruction of the present study can be attributed to this bird. Ravens, however, are present at times, and it is possible that this species may be responsible for some waterfowl nest predation attributed to crows. It is believed that the appearance of eggs destroyed by both species would be similar.

Bump et al (1947) does not differentiate between the sign left at a destroyed grouse nest by weasel or mink. If tooth marks are present on shell remains these probably would permit easy separation of the two mammals.

Unknown

Thirteen nests (five ring-necked duck, four black duck and four artificial) were destroyed by predators that could not be identified with reasonable certainty. Ten of these appeared to have been destroyed by mammals, and three by birds.

SUMMARY

The following diagnostic characteristics appear to be the most helpful for identifying the predators of duck nests in Maine observed during the present study. Incidence of the types of nest destruction is summarized in Tables 1 and 2.

Raccoon.—Nest structure nearly always pawed, commonly quite extensively. Shells present, usually within six feet of the nest. Shell remains broken (as opposed to crushing) usually in half, occasionally split lengthwise. Hair usually present on nearby vegetation. Duck nests in almost any kind of habitat are susceptible to raccoon predation.

Mink.—Nest structure intact. Shells present, usually near nest. Eggs may be nearly entire, with only a small hole eaten out of end, or may be considerably broken. Edges of shell finely chewed.

TABLE 1.—PREDATORS RESPONSIBLE FOR NEST DESTRUCTION

Predator	Artificial Nests	Black Duck Nests	Ring-necked Duck Nests	American Goldeneye Nest	Total
Raccoon	10	1	8	1	20
Mink	—	1	3	—	4
Skunk	2	—	—	—	2
Red Fox	4	4	—	—	8
Unknown Mammal	4	3	2	—	9
Crow	6	1	—	—	7
Type of predator undetermined	—	1	3	—	4
Total	26	11	16	1	54

TABLE 2.—RELATIVE ABUNDANCE OF SIGN AT DESTROYED NESTS

	Artificial Nests	Black Duck Nests	Ring-necked Duck Nests	American Goldeneye Nest	Total
Destroyed nests studied	26	11	16	1	54
Destroyed by mammal	20	9	13	1	43
Destroyed by crow	6	1	—	—	7
Unknown predator	—	1	3	—	4
TYPE OF SIGN PRESENT					
Egg Shells	21	3	15	1	40
Hair	16	6	9	1	32
Feathers	1	—	—	—	1
Droppings (mammal)	3	—	—	—	3
Tracks (mammal)	1	—	—	—	1

Small tooth marks often show on unbroken portions of the shell. Hair may be present. Nests in aquatic habitat are most susceptible.

Skunk.—Nest demolished. Shells present, completely crushed (as opposed to broken), fragments clinging together in a shapeless mass. Hair usually present—including long white, guard hair. Nests in upland or dry habitat are most susceptible. Skunk odor may be present.

Red fox.—Nest generally deranged but seldom demolished, the rim most commonly being pulled out on one side. Broken egg shells ordinarily not present. Hair usually may be found on nearby vegetation. Nests in dry or semi-aquatic habitat are most susceptible.

Crow.—Nest may have one side pulled out and scattered a few feet but often is undisturbed. Parts of egg shells generally present—possibly only very small fragments in the nest. All eggs are seldom accounted for; shells may be found beneath nearby trees or in open portions of a marsh. Egg usually retaining its spherical shape, with a moderate or large opening in the side. Generally there is a smaller puncture just below and to one side of the large opening, caused by the lower mandible of the bird. Duck nests in a wide variety of habitat are susceptible to crow depredations.

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BIOLOGY OF THE ELK CALF, *CERVUS CANADENSIS NELSONI* [1]

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Introduction

Rush (1932), Young and Robinette (1939), Schwartz and Mitchell (1945), and others have contributed much to our knowledge of elk but very little quantitative information pertaining to the individual calf is available. The present paper attempts to supplement the available information.

The Gallatin elk herd, which ranges in the upper West Gallatin river drainage of southwestern Montana and northwestern Yellowstone National Park, provided an excellent opportunity for concentrated study. It is one of the more important herds in the United States. The average winter count for the period 1939 through 1949 was 1,700 while the average annual harvest over the same period was 550 (Angstman and Gaab, 1950). These elk are roughly divided into two groups, migratory and resident. The migratory animals, comprising the larger segment of the population, summer in the high "back" country of Yellowstone Park at elevations up to 10,000 feet. They winter along the northwestern park boundry at an elevation of approximately 7,000 feet, and within the Gallatin National Forest at elevations between 6,500 and 7,500 feet. The resident animals are distributed within the Gallatin Forest and apparently do not take part in the extensive seasonal movements. During the summer of 1949 and 1950 a study was made of the calves, particularly those of the migratory herd.

Thanks are extended to the Montana Fish and Game Department for permission to conduct the study, for financial support, and equipment. Other members of the department, to whom acknowledgments are due, are: J. E. Gaab, R. L. Hodder, V. E. Sylvester, J. B. Angstman, and A. R. Brazda for aid in the field. The writer further extends his grateful appreciation to Dr. Don C. Quimby, Montana State College, who directed the study.

Methods

To study the calves in the field a suitable marking technique for recognition of individuals is desirable. A review of the literature on animal marking (summarized by Manville, 1949) failed to reveal a liquid marking material which would be suitable for the study. An attempt was made to find such a material. Forty Hereford steers were experimentally marked with commercial house, auto and sheep branding paints, aniline dyes, inks and various bleaches. None exhibited all of the desired properties; color fastness, retention to the hair, ease of application and visibility.

Marking mammals and birds with plastic symbols has been recorded by Trippensee (1941) and Hosley (1942).

[1] A joint contribution from Montana State College, Agricultural Experiment Station, Project No. MS844, Paper No. 241 Journal Series and the Wildlife Restoration Division, Project 35R, Montana Fish and Game Department.

Following their principles, colored plastic ear markers attached by livestock ear tags were used. (Howitt Plastics Company, Portland, Oregon supplied the material.) The color of the symbols indicated the year the animal was tagged; red and white for 1949 and blue and yellow for 1950. Manipulation of colors and shapes provided 48 combinations. Two inch squares, circles, half circles or triangles either plain or with 1 inch inner symbols of the same shapes cemented by acetone were used (Plate 12B). Each symbol, when duplicated for attachment to the opposite ear, doubled the total number of possibilities. The shape of the outer symbol indicated the drainage where a calf was tagged while the inner symbol identified the individual animal, except when certain large symbols alone identified both individual and drainage.

Locating the recently born calves was accomplished by searching the sagebrush slopes and timber edges during May and June (Plate 12C) on horseback and at the same time observing unusual actions of singles or small groups of females which occasionally indicated the presence of calves in the vicinity. By blowing across a blade of grass held taut between the thumbs and heels of the hands a tone, similar to the call of a calf, was created. This tone appeared to excite the female elk and many times their suspicious actions disclosed the location of their calves.

The calves were tagged in both ears, one with a numbered metal stock tag only, the other with a numbered metal stock tag to which a plastic marker was attached (Plate 12A). Weights with a steelyard or spring scales, standard measurements with a steel tape, dental observations and notes concerning physical characteristics were obtained.

Following the calving period, additional data were collected by observing the marked calves through 6 and 8 power binoculars and a 20 power spotting scope. To make these observations, it was necessary to follow the migrating herds to their summer range, with saddle horses and a pack outfit. Some supplementary information was secured by observing a captive calf.

General Description of Calving Area

The major part of this calving area is drained by a 19-mile segment of the West Gallatin River and 6 of its tributaries (Taylor Fork, Tepee Creek, Daly Creek, Sawmill Gulch, Lodgepole Gulch, and Fan Creek). The area is characterized by broad open slopes with open timber stands. Big sagebrush (*Artemisia tridentata*) is the dominant plant in the open areas while Lodgepole Pine (*Pinus contorta*) is the dominant timber species. The timber stands, which often become very dense on north exposures, may be made up of mixtures of Douglas Fir (*Pseudotsuga taxifolia*), Quaking Aspen (*Populus tremuloides*), Engelman Spruce (*Picea engelmanni*) and Lodgepole Pine. Other plants found in the calving area are as follows: grasses and sedges—*Festuca idahohensis, Stipa* spp., *Koeleria cristata, Carex* spp., *Bromus carinatus, Agropyron smithii, A. spicatum, Calamagrostis rubescens, Elymus condensatus;* shrubs—*Artemisia cana, Dasiphora fruticosa, Chrysothamnus* spp., *Gutierrezia* spp., *Arctostaphylos uva-ursi, Salix* spp.; forbs—*Lupinus* spp., *Phlox* spp., *Antennaria* spp., *Aster* spp., *Achillea lanulosa, Potentilla* spp., *Eriogonum* spp., *Fra-*

garia spp., *Erythronium* spp., *Dodecatheon pauciflorum*, *Erigeron* spp.

Elevations within this area range from approximately 6,700 feet to 10,000 feet. Maximum calving elevations found during this study, however, did not exceed 9,000 feet, with the bulk of the calves found between approximately 7,000 feet and 7,400 feet.

Associated with this calving area are various mammals of which elk, moose, mule deer, coyote and black and grizzly bear can be included as major influents. In addition, porcupine, woodchuck, golden-mantled and armatus ground squirrels, chipmunk, red squirrel, beaver, muskrat, badger, pika, and snowshoe hare are encountered. On one occasion two buffalo were observed.

CALVING

Calving Period

By estimating the age of the calves when found, using physical characteristics (Table 1), calculated birth dates were determined and the calving period delimited. Extremes were May 21 and June 12 with the peak of births for the two years occurring June 1 (Fig. 1). In northern Idaho, a June 1 peak was also reported (Rust, 1946). Rush (1932) found extremes on the northern Yellow-

TABLE 1.—CHARACTERISTICS USED FOR AGE CLASS DETERMINATION OF ELK CALVES

Age Class	Characteristics		
	Moisture on Hair	Dentition	Navel
A (newborn & 1 day)	Wet or dry & matted. Dampness inside ears.	*Front Incisors* covered by membrane or protruding through membrane 1/8″ or less. *Upper Canines* — not through. *Cheek Teeth* — not through or barely so.	Bloody, moist, approx. 1/2″ to 3/4″ dia.; not scabbed. Portion of umbilical may or may not be present; if present, moist.
B (2 through 4 days)	Dry *	*Front I's*—protruding 1/8″ to 1/4″. *UC's* not through. *CT* — just through or protruding approx. 1/16″ or less.	Bloody or lightly scabbed about 1/2″ dia. Portion of dried umbilical may be present.
C (5 through 7 days)	Dry *	*Front I's*—protruding 1/4″ to 3/8″. *UC's* barely through. *CT*—through gums over 1/16″.	1/2″ to 1/4″ dry scab.
D (8 days & over)	Dry *	*Front I's*—protruding 3/8″ to 5/8″. *UC's* just through or protruding approx. 1/8″ or more. *CT*—same as above only more so.	1/8″ to 1/4″ scab or entirely healed.

TABLE 1 (Continued).—CHARACTERISTICS USED FOR AGE CLASS DETERMINATION OF ELK CALVES

Age Class	Characteristics		
	Hooves	Dew Claws	Stature & Stability
A	Entirely soft or less than ½ hoof hardened. Walking surface ragged with slight to no grass staining present.	Entirely soft & brittle or only upper ¼" hardened.	Unable to stand or very insecure & wobbly on feet. Legs spread well apart if standing. Somewhat humped posture when standing.
B	All hardened; walking surface smooth (not ragged & showing much grass staining.	Entirely hard or just the extreme tips soft.	Somewhat wobbly to very sturdy. Posture generally erect.
C	Same as above	Entirely hard	Very sturdy & erect.
D	Same as above	Same as above	Same as above

* Moisture may be present on the calf if it has been recently licked by the cow. If licked during nursing generally only the posterior regions of the calf will be moist.

stone herd of May 13 and June 10, while Schwartz and Mitchell's (1945) were May 14 and July 10, during their Olympic Peninsula study.

Some late calving was suspected in the Gallatin when 2 calves were observed on July 12 and July 14, respectively, which were much smaller than other calves in the same groups. These calves appeared sturdy and well developed but neither seemed to exceed the size of calves which were being aged at 5 and 6 days during the tagging operation in May and June. A late birth observation was recorded by Schwartz and Mitchell (1945) on July 10 for the Roosevelt elk. Among white-tailed deer in New York, Cheatum and Morton (1946) indicate that late births resulted from two factors; recurrent estrus among adult females and fawn breeding. No evidence of calf breeding among elk is known to the writer. Heape reported that the female elk (*Cervus canadensis*) "in captivity" experiences a continuous series of diestrous cycles lasting three weeks (from Asdell, 1946). This could explain the late calves observed in this study, if the same cycle is exhibited by wild elk.

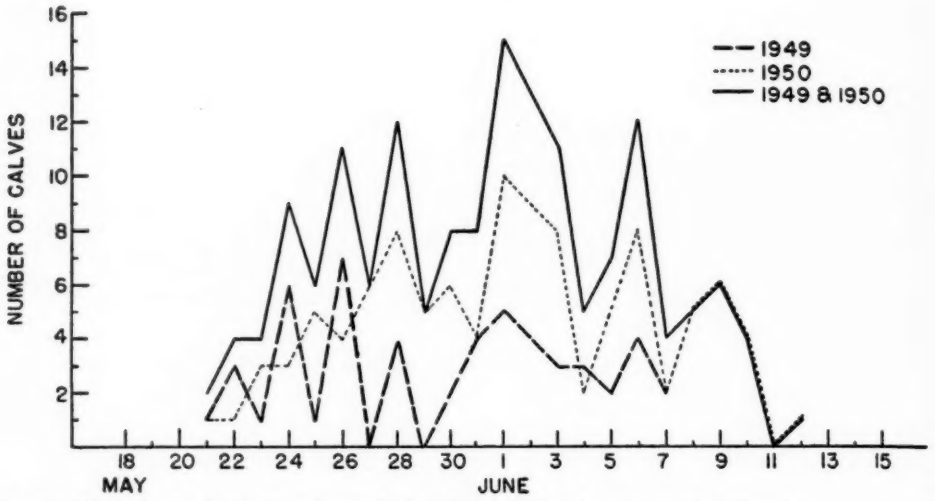

FIG. 1. Birth dates of 158 elk calves calculated from approximate age when found.

All evidence encountered during this study indicated female elk gave birth to only 1 calf per season. Asdell (1946) reported 1 is the usual number, "but occasionally 2 and 3" are born at a time. "Twins are uncommon" according to Rust (1946). Both Rush (1932) and Schwartz and Mitchell (1945) found no evidence of twin pregnancy.

Relation to Cover Types

The calving area in the Gallatin is located mainly on the upper limits of the winter range, as was also found to be the case in other areas studied (Rush, 1932, Darling, 1937, Young and Robinette, 1939, and Rust, 1946). It consists of several vegetative types. The more important calving types are as follows: sagebrush (*Artemisia tridentata*), timber (*Pinus contorta, Populus tremuloides* or both), sagebrush and cinquefoil (*Dasiphora fruticosa*), cinquefoil and grass (*Festuca* spp., *Stipa* spp., *Agropyron* spp.), sedge (*Carex* spp.), sedge and low willow (*Salix* spp.), low willow and "edge." The ecotone between sagebrush and timber is referred to as the "edge type" in this study. Three types exhibit more xeric characteristics than the others, sagebrush, timber and edge.

Calves are recorded in Fig. 2 according to the vegetative type where they were found. Newborn calves are recorded separately. Approximately 77 per cent of all calves were found in sagebrush types, 11 per cent in timber and 4.5 per cent on the edge of timber and sagebrush. For the newborn calves the percentages were 42, 33, and 25, respectively. The data for newborn calves are more indicative of place of parturition than that for all calves because very probably they had not moved. In this sample, however, the data for all calves support that of the newborn with regard to preference for drier sites.

It also appears that the relationship of open and timber types to each other is very important, e.g., the distances calves were found from the boundaries of these type groups. The distances

PLATE 12. A. An ear marker attached to an elk calf (note metal stock tag on opposite ear). B. Plastic ear markers showing all combination arrangements for two drainages (squares and circles), a few for half circles and triangles. Two numbered metal stock ear tags are shown in upper left hand corner. C. Riders searching for calves in a sagebrush type on the calving ground, showing approximate interval used. D. Weighing a calf using a steelyard.

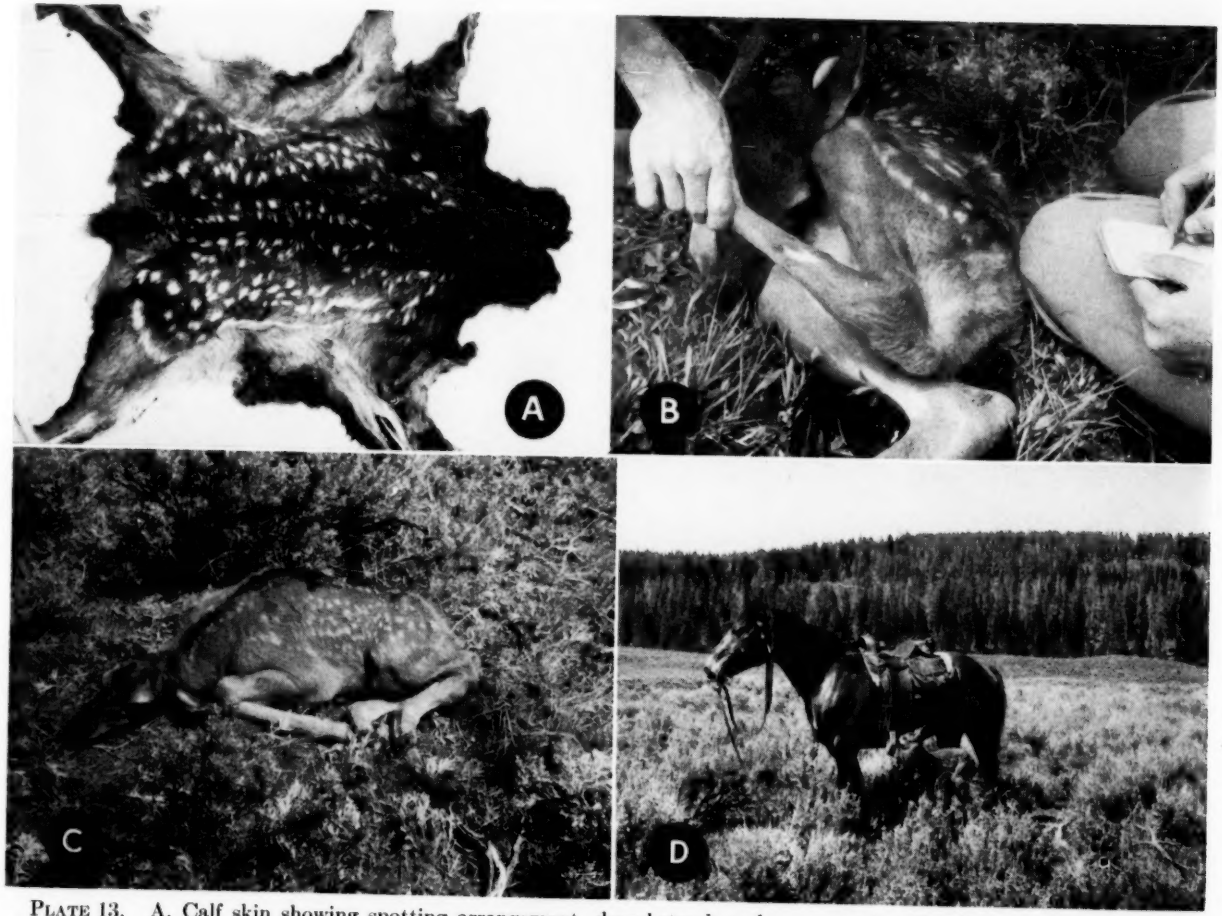

PLATE 13. A. Calf skin showing spotting arrangement, dorsal streak and rump patch. B. Elk calf showing prominent metatarsal gland (also note ear tag and marker). C. Elk calf hiding in a sagebrush type. D. Elk calf, after release, following horse.

calves found in open areas were from the timber, ranged from 0 (edge) to 500 yards, with a mean of 73.7 yards. The distances calves found in timber were from the open areas ranged from 0 to 40 yards; the mean, 10.0 yards. During the calving season, the vast open sagebrush types seemed to be most productive (yield the greatest number of calves) only in those portions in close proximity to timber. This illustrates the importance of "edge effect" and appears to emphasize Leopold's (1933) "law of interspersion."

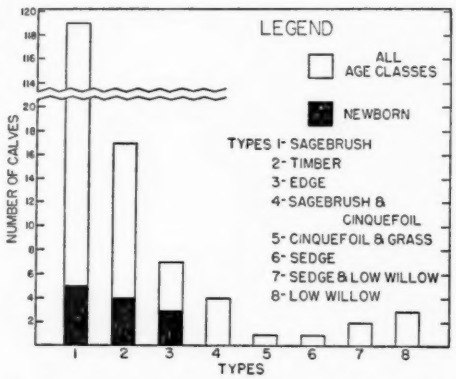

FIG. 2. Vegetative types where 154 elk calves were found.

PHYSICAL CHARACTERISTICS

During the calving season certain differences were recognized among the calves. After handling a relatively small number, it was readily seen that these were due to differences in ages. In the field all physical characteristics for each calf were recorded, particularly those pertaining to the amount of moisture on the hair, dentition development, condition of navel, hardness of hooves and dew claws, and general stature and stability. After calving season, all similar physical characteristics were grouped. Certain limits of development were immediately observed from the data thus delimiting ranges for specific age classes. Table 1 contains the final compilation of these data according to age classes, as accurately as is possible from the data available.

Weights and Standard Measurements

Each calf was weighed and measured in the field by methods described previously. Means and ranges of weights and standard measurements (total length, tail, hind foot and ear) determined for each age class are recorded in Table 2. Obviously, weights and measurements are not sufficient for determination of age of calves as shown by the range of extremes for the various age classes.

Weights and estimated daily ages were recorded for 22 Rocky Mountain elk calves in the Sun River area of Montana by R. F. Cooney in 1939 (personal communication). Although the means exceeded those of Gallatin calves, individual weights fell well within the range of Gallatin extremes.

Rush (1932) reported that "the average weight of a calf at birth is 37 pounds . . .", with extremes of 23 and 45 pounds. This average weight exceeds the Gallatin mean by 4.5 pounds. "Typical measurements" for a 3–5 day old Roosevelt elk were given by Schwartz and Mitchell (1945) as follows: 37.0–1.5–16.5–4.75 inches. This elk (*Cervus c. roosevelti*) is reported by the same writers as larger than the Rocky Mountain elk although calf measurements for both are very similar.

Average weights of male calves exceeded female calves as follows: Age Class A, 4.41 pounds; B, .22 pounds; C, 2.62 pounds; and D, .34 pounds.

TABLE 2.—WEIGHTS AND STANDARD MEASUREMENTS OF ROCKY MOUNTAIN ELK CALVES

	Weights (in pounds)			Standard Measurements (in inches)			
				Mean and Range			
Age Class	Number of Calves	Mean and Range	Number of Calves	Total Length	Tail	Hind Foot	Ear
A (Newborn through 1 day)	23	32.5 (19–45)	23	38.31 (30.0–44.0)	2.05 (1.5–2.75)	15.46 (14.0–17.0)	4.38 (4.0–5.0)
B (2 days through 4 days)	48	36.08 (21–48)	49	39.98 (36.0–45.75)	2.23 (1.75–3.0)	15.7 (13.5–16.75)	4.42 (4.0–4.75)
C (5 days through 7 days)	47	44.71 (34–59)	49	42.36 (38.0–46.25)	2.24 (2.0–2.75)	16.2 (15.25–17.25)	4.7 (4.25–5.0)
D (8 days and over)	22	53.18 (40–79)	22	44.32 (41.5–49.5)	2.29 (2.0–3.0)	16.61 (15.25–17.5)	4.77 (4.5–5.25)
Totals	140		143				

Sex Ratio

Sex ratio data were secured from 155 calves during the study. This information, combined with data obtained by other authors, is listed in Table 3.

These data do not support the suggestion of Banfield (1949) that there is a high male prenatal mortality. The findings of the present study strongly suggest a near one to one sex ratio which is supported by the large sample of Angstman and Gaab (1950).

Coloration

Coloration of the calf pelage may vary considerably from a uniform reddish-buff color with very indistinct spotting (Calf No. 91) to an exceedingly dark brown with brilliant spots. The typical calf coloration is light brown with a dark brown to black streak approximately 1-1/2 inches wide. It usually extends from about 1 inch behind the ears to the edge of the buff colored rump patch. This patch extends forward approximately 4 inches from the tail root and covers the posterior portion of both thighs. Usually 1 row of white spots parallel the dark streak on either side of the midline. Irregular spotting occurs on the sides but never overlapping into the rump patch (Plate 13A). Occasion-

TABLE 3.—CALF SEX RATIOS FOR THREE SUBSPECIES OF *Cervus canadensis*

Authority	Subspecies	No. in sample	Sex Ratio ♂♂ : 100♀♀
Angstman and Gaab (1950)	*nelsoni*	470	97 : 100
Present study	*nelsoni*	155	96 : 100
Rust (1946)	*nelsoni*	unk.	89 : 100
Schwartz and Mitchell (1945)	*roosevelti*	94	64 : 100
Banfield (1949)	*manitobensis*	10	25 : 100

ally the dorsal streak may be indistinct or absent and only extend part way to the rump patch.

Glands

Hamilton (1939) describes four skin glands of the deer tribe. Two of these are prominent on the elk calf. The preorbital gland, continuous anteriorly and ventrally with the orbit, is approximately 1/4 inch in diameter and 1/4 inch deep. The metatarsal gland, is situated approximately 5 to 6 inches below the flexed metapodial joint on the outside of each hind foot (Plate 13B). It is approximately 1-1/2 inches long and 3/4 inch wide and consists of a tuft of white hair surrounded by longer hair of the same color as the pelage. From the observations this gland, on the young calves, is odorless to the human nose.

Odor

Apparently the newborn calves are odorless. Three days during the 1949 calving period a German Short Hair Pointer accompanied the tagging crew and failed to locate any calves. Once he was observed to pass within 5 feet of one. A newborn calf which was found entirely wet (approximately 4 hours old) gave off no detectable odor to the fieldmen. Older calves, completely dry, also failed to have a noticeable odor except that of the sagebrush in which they were generally lying. Rush (1932) reports that a horse was observed to graze within a foot of a hiding calf without smelling it.

Reactions

Calves, when approached, are generally found hiding in the sagebrush (Plate 13C). When observed from a distance through binoculars they are seen to move their heads and occasionally even change positions but when approached they become motionless. This behavior is seemingly of a protective nature because they are difficult to see in the motionless position. It has been observed that they often obtain an apparent sense of security when a piece of sagebrush is placed over their heads even after being handled.

The keenness of the senses is difficult to evaluate by observations. Two newborn calves were observed to walk out of the timber to the riders. It was not uncommon to see calves approach and follow horses after being released (Plate 13D). The calves on other occasions ran to the cows when the latter were standing within sight or hearing range of the released calves.

Voice

The call of the calf is very high-pitched, shrill and emitted for short durations at rather frequent intervals. This sound was heard when the animals were being handled and also when large numbers of elk were moving or disturbed. Murie (1932) recorded, "The call of the elk calf may be written E-e-e-e-e-uh!."

Development

Certain aspects of calf development were observed in the wild and from one captive. Weights and measurements were recorded each time a tagged wild calf was recaptured. Approximately every two weeks a captive calf was weighed and/or measured. The average daily weight increase for 16 wild calves was 2.0 (.83 to 3.12) pounds, while average daily measurement increases

were: .69 (0.0 to 1.75) – .01 (0.0 to .04) – .10 (0.0 to .25) – .03 (0.0 to .06) inches. These increases were based on observations extending over periods of 2 to 14 days. The captive calf, which was reared on domestic cow's milk, showed smaller increases: weight 1.0 (.37 to 1.62) pound; measurements .21 (.19 to .24) – .01 (0.0 to .02) – .05 (.04 to .06) – .01 (0.0 to .03) inches per day over a 31 day period. The weight of this calf on August 10 was 77 pounds, showing an average gain of 1.0 pound per day over the 53 day period. Over approximately the same period measurement increases were .29–.01–.04–.02 inches per day.

Five weights and 9 measurements were secured from calves approximately 7 months old during December 1949 in Yellowstone Park (some of these data previously published, Quimby and Johnson, 1951). Average standard measurements were 67.8 (61.25 to 75.75) – 4.78 (4.0 to 5.5) – 22.36 (20.25 to 24.0) – 7.14 (6.75 to 7.5) inches. Total weight, 251.5 pounds, was secured for one. For 4 others, the calculated total weights from visceral weights were 234, 291, 195 and 246 pounds where visceral weight is 1/3 of total weight (Quimby and Johnson, 1951).

Calf spotting, which generally becomes very distinct shortly after birth, is lost during the first pelage molt in August and September. The first evidence of adult shedding was observed August 5 while calf shedding was first observed August 11. Spotting fades gradually from the dorsal parts ventrally until complete disappearance. The first observation of a completely molted calf was August 17. No calves were observed with spots after September 7; the pelage was generally lighter colored and very similar to that of the yearling.

ACTIVITIES

Walking

Nine of 12 newborn calves were unable to walk and 3 of these unable to stand. The calves capable of walking were very unstable and unable to progress more than a few yards. Six calves, approximately 1 day old, did not attempt to stand, while 5 ran unsteadily after being handled. Seemingly the calves do little moving until about the third or fourth day at which time they are generally good runners. After 6 or 7 days the calves must be approached cautiously as they are quick to gain their feet and are very fast runners.

Swimming

Only 1 calf was observed swimming. This calf, approximately 4 days old, was hidden on the opposite side of the river from the grazing cow. After it was tagged and released the calf ran upstream approximately 100 yards, jumped into the swollen river, which was about 4 feet deep and 60 feet wide, and swam across to the cow. Rush (1932) and Schwartz and Mitchell (1945) both reported calves swimming.

Nursing

Calves were first observed to nurse on June 27. Throughout the study no definite nursing pattern was apparent. Duration of nursing ranged from less than 30 seconds to 1-3/4 minutes, evidently at the cow's discretion. On July 1, a yearling was observed to nurse for approximately 30 seconds, assuming a kneeling position. Rush (1932) reported a similar observation on July 19.

Darling (1937) reports both yearling and calf nursing the same hind (cow) as not at all unusual among Scotland's red deer (*Cervus elaphus*). For the nursing calves the kneeling position, as well as the standing position, was commonly observed after August 7. After August 2, "practically all of the calves observed nursing" by Young and Robinette (1939) were in kneeling positions.

Between December 20 and 29, 1949, 46 female elk over 2 years old were examined (data secured in Yellowstone National Park and published with their permission). Twenty were found to be lactating while the remainder were dry. From these few data it would appear that a high percentage of the calves were still nursing.

Grazing

One captive and 2 wild calves were observed grazing June 26 and 27, respectively, when approximately 3 to 4 weeks old. Intense grazing by calves was not commonly observed much before July 10 (6 to 8 weeks of age). This is similar to the findings of Rush (1932) and Young and Robinette (1939) although somewhat later than those reported by Schwartz and Mitchell (1945).

Play

On four occasions Gallatin elk calves were observed playing a type of tag; first one chased the other, then vice versa. Twice calves were seen to play this game in shallow pools. Similar antics were reported for Idaho elk calves by Young and Robinette (1939). Darling (1937) described 4 types of play observed among the red deer calves of Scotland, one of them being this game of tag.

Relationship to Cow

A very close relationship between cow and calf was observed throughout the study with a few exceptions. Four cows were observed with 13 calves (no other adult females in the immediate area). This may have been an example of certain cows acting as "guards" while others were grazing (Schwartz and Mitchell, 1945) or serving in the capacity of "nursemaids" as reported by Einarsen (1948) among antelope. Two calves were observed playing alone on a lake shore August 18 approximately 1/2 mile from the herd. When frightened, they quickly rejoined the others.

Movements

This portion of the study was aided by the use of plastic ear markers previously described. One hundred thirty-two calves were marked. When a marked calf was observed or killed by a hunter, its location was recorded. Airline distance from the place of tagging was then calculated (Table 4).

Airline distances could be recorded quite accurately when individual identifications could be made but in cases where the drainage symbol only was recognizable they were approximate.

Thirty-two observations were recorded at distances from 0 to 19 miles from the calving area during the two years, as follows: 3 in June, 7 in July, 4 in August, 12 in November, 4 in December and 2 in January. For the summer months all observations were at generally higher elevations above the calving grounds. The average distance for June was 3 airline miles, 11 for July, and 8 for August. Observations for November and December were below the calving area, 3 and 2 airline miles, respectively. One

observation in January was 4–5 miles above the calving ground, while the other was in another drainage 18 miles away. These data suggest the general pattern of elk migration for this drainage; i.e., the calves are born on the upper winter range after which they begin a movement to the generally higher elevations of the summer range. The maximum elevations are reached in July. During August the direction of movement is reversed. In November and December the animals are on the winter range generally at elevations lower than the place of birth.

TABLE 4.—OBSERVATIONS OF TAGGED CALVES

Calf No.	Date Tagged	Date Observed	Movement (miles)
24	6–12–49	6–28–49	2–3
29	6–12–49	6–28–49	2–3
21	6– 4–49	7–26–49	8
31	6– 4–49	8– 5–49	5–6
unk.	unk.	12– 1–49	approx. 0
unk.	unk.	12– 1–49	approx. 1
unk.	unk.	12– 1–49	unk.
75 *	6– 6–49	12–21–49	3–4
3	6– 3–49	1–12–50	4–5
29 **	6–12–49	1–19–50	18
167	6– 2–50	6–28–50	2–3
unk.	unk.	7– 9–50	approx. 11
127	6–11–50	7–11–50	11–12
148	6– 9–50	7–11–50	10
83	6– 1–50	7–15–50	9
136	6– 3–50	7–15–50	8
unk.	unk.	7–26–50	approx. 17
unk.	unk.	8– 8–50	approx. 8
unk.	unk.	8– 8–50	approx. 12
unk.	unk.	8– 8–50	approx. 8
unk.	unk.	11–10–50	approx. 2–3
unk.	unk.	11–10–50	approx. 1
23 *	6–12–49	11–13–50	18
140 *	6–10–50	11–15–50	1
78 *	6– 6–49	11–17–50	1–2
158 *	5–30–50	11–21–50	0
126 *	6–11–50	11–23–50	4
128 *	6–11–50	11–24–50	3–4
107 *	6–11–50	11–24–50	3–4
163 *	6– 3–50	11–24–50	0
99 *	6– 2–50	11–24–50	6
120 *	6–11–50	11–24–50	3–4

* Hunter kill.
** Moved out of Gallatin drainage.

The above data indicate a true migration involving a movement away from and return to an area. One observation for January is atypical in that this animal was trapped in the Yellowstone drainage which supposedly supports a herd distinct from the Gallatin herd. Other data suggesting an intermingling of the two herds are available from calves marked on the Yellowstone during the spring of 1950 by the Montana Fish and Game Department. About 60 were marked with striped plastic ear markers. Twelve were observed on the same summer range (high range between the Yellowstone and Gallatin drainages) used by a portion of the Gallatin herd. The Yellowstone calves had moved about 9 to 13 airline miles from the tagging area.

EFFECTIVENESS OF THE MARKER

Hunter kills and observations late in the season provided information on the durability of the markers. To date, 8 calves tagged in 1949 have been observed or killed after the first summer. Three had retained the marker for 6 months and 1 for 7-1/2 months. On the negative side, 1 calf had lost the marker by 7-1/2 months after tagging. One killed in December 1949 had lost both metal and plastic tags. One ear was split. Two other 1949 calves killed during November 1950 had no markers. All markers used during the 1949 season were of a thin celluloid nature and seemingly less durable than the thicker plastic markers used in 1950. No completely negative results have been found for the 1950 markers. Eight had remained 6 months on calves killed in November 1950. Six were in perfect shape. Two symbols were damaged: a large triangle

had a corner broken off and only 1/3 remained of a large circle. Both damaged symbols showed breaks which were very smooth and clean, possibly indicating they were broken while in the hands of the hunters. From these few data, it appears that the plastic type marker showed considerable promise for big game mammal marking as far as durability was concerned.

The maximum range of visibility for positive identification of the smaller symbols (individuals) was approximately 100 yards with 6 or 8X binoculars. Ranges approaching 200 yards were not found excessive using a 20X spotting scope if caution was exercised. These ranges can be altered appreciably due to the extent of timber cover, daylight brightness and animal movements. Identification of outer symbols (drainages) has been made at 250 to 350 yards with 20X and at 150 to 200 yards with 6X, both under rather poor light conditions. Trippensee (1941) recorded a table of ranges of visibility for colored markers of generally smaller size used on small game. Some were easily distinguishable at 5 to 300 feet with naked eye, 8X or 10X glasses.

ADVERSE FACTORS

All suspected predation or accident observations encountered during this study are recorded in Table 5 with three observations made by Montana Fish and Game Department personnel in 1948. Two cases of black bear predation were actually observed (Cases 1 and 2), both in 1948. Cases 4 and 9 appear to fit Murie's (1948) descriptions of bear inflicted wounds on cattle in which he found injuries in the lumbar region of the back and in the facial region. The lumbar punctures in Case 4 on one side were 3 inches apart and 2-1/2 inches on the other side. These measurements are similar to those found on a yearling domestic cow by Murie, which strongly suggests that the Gallatin case was an unsuccessful attack by a bear. Cases 5 and 6 showed no evidence of injuries.

TABLE 5.—MORTALITY RECORDS FOR ELK CALVES

Case No.	Date	Cause of Death	Remarks
1	6– –48	Black Bear	Observed killing calf. Tooth punctures on either side of spine in lumbar region. Two long wounds left front shoulder (by J. E. Gaab).
2	6–12–48	Black Bear	Observed killing calf (by G. H. Sherman).
3	6–10–48	Unknown	Black bear observed eating on calf carcass (by J. E. Gaab).
4	6–13–49	Bear (?)	Calf found alive—died during day. Deep wound, 3″ long, penetrating left thigh. Two punctures on either side of spine in lumbar region penetrating body cavity.
5	6–11–50	Unknown	No external signs of injuries. Carcass intact.
6	6–11–50	Unknown	No external signs of injuries. Carcass intact.
7	6–13–50	Unknown	Calf dead several days—carcass approx. ⅓ devoured. Injuries, if any, not determined.
8	6–14–50	Unknown	Carcass scattered and badly deteriorated. Injuries, if any, not determined.
9	6–16–50	Unknown	Head badly lacerated, rostrum crushed. Dentary broken, tongue severed approx. 1½″ from tip except for small portion ½″ wide. No body injuries observed.
10	6–25–50	Drowned (?)	Found dead in creek approx. 2′ wide and 3′ deep. No injuries observed.

Schwartz and Mitchell (1945) found a few dead young each calving season, the cause of which they attributed to general weakness or pneumonia. Although rough field analyses of bear scats were frequently made, no calf remains were identified. Eight per cent of more than 100 bear scats examined by Schwartz and Mitchell (1945) contained evidence of fawns in the diet. No evidence of coyote predation was encountered in the Gallatin although an attempt, unsuccessful due to the aggressiveness of the cow, was observed.

One accident record was suspected (Case 10) when a calf was found dead in a steep-sided creek but no evidence of injuries were found on its body.

Between 1939 and 1949 the average annual calf harvest by hunters was 91 animals for the Gallatin (Angstman and Gaab, 1950). Of the 132 calves marked 11 are known to have been killed during the regular hunting seasons (1 during the 1949 season, 10 during the 1950 season). Both seasons were controlled with kills set at 700 head each year.

Intense insect infestations appear to be a major nuisance factor in July and August. During this time the high windy ridges are seemingly desired by the elk. If such areas are unavailable some protection from the insect attacks is evidently obtained by bedding down in tall sedge meadows.

SUMMARY

1. A study of elk calves was conducted during 1949 and 1950 in southern Gallatin County, Montana and the northwestern portion of Yellowstone National Park.
2. A description of the calving ground is given with reference to location, vegetation, topography, climate and associated mammals.
3. Calving areas were covered on horseback to find the calves; weights, standard measurements and other biological data were obtained.
4. One hundred thirty-two calves were tagged with numbered metal stock ear tags and colored plastic markers composed of a large outer symbol alone or combined with a smaller inner symbol of contrasting color. Combinations of shapes, colors, sizes and ear to which it was attached identified the individual and drainage where tagged. Observations were made after the calving season particularly on the marked calves.
5. The range and peak of the calving period was found to be May 21 to June 12 and June 1, respectively.
6. A few specific vegetation types were found to contain most of the calves: sagebrush types, 77 per cent; timber, 11 per cent; and "edge," 4.5 per cent. The average distance calves found in open areas were from timber was 73.7 yards, while those in timber averaged 10.0 yards from open areas, illustrating the importance of "edge effect."
7. According to age classes, determined by physical characteristics, the average weights of calves were: newborn–1 day, 32.5; 2–4 days, 36.08; 5–7, 44.71; and 8–over, 53.18 pounds. Average standard measurements for the same age classes were: 38.31–2.05–15.46–4.38; 39.98–2.23–15.7–4.42; 42.36–2.24–16.2–4.7; and 44.32–2.29–16.61–4.77 inches.
8. Weights of male calves were found to exceed those of females for the

above age classes as follows: 4.41, .22, 2.62, and .34 pounds, respectively.

9. For 155 calves examined, the sex ratio was 96 males : 100 females.

10. Descriptions of coloration, glands, odor, reactions and voice are discussed with some illustrations.

11. Average daily weight and measurement increases for 16 wild calves for the first two weeks were 2.0 pounds and .69–.01–.10–.03 inches, respectively. One captive calf gained, on the average, 1.0 pound daily and increased .21–.01–.05–.01 inches per day over a 31 day period.

12. Certain activities such as walking, swimming, nursing, grazing, etc. are discussed.

13. The average monthly distance that marked calves were observed from the calving grounds illustrated the general pattern of elk migration in the Gallatin drainage.

14. Observations of 1949 markers (celluloid) showed 4 negative results in 8 late observations, while the 1950 marker (plastic) showed no completely negative results for the same number of observations, although 2 markers were damaged.

15. Observations of predation were limited to 2 suspected bear attacks on calves during the study, but 2 1948 bear kills are recorded. Insects appeared to be a major nuisance factor in the summer. Hunter kills presented the greatest mortality factor during the fall. The average annual calf harvest for the last 10 years was 91 animals.

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AN ANALYSIS OF ANIMAL VICTIMS ON NEBRASKA'S HIGHWAYS *

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INTRODUCTION

The kill of animals along roadsides by rapidly moving vehicles has long been recognized. In areas of wildlife concentrations it amounts to considerable loss. During the period Jan. 1941 thru April 1944 the author traveled 77,000 miles over Nebraska highways. Nebraska has a large wildlife population and while its highway travel is not as intense as that in more heavily populated states, highway losses to wildlife are great. In recognition of this, records were kept of all identifiable remains found as well as the type of road surface, adjacent cover or crops, and time of year.

Heavy kills or unusual losses have attracted comment by many observers. Gordon (1932) reported kills of jackrabbits as great as 100 per mile in the vicinity of Thousand Springs, Idaho. Unusual specimens are occasionally found along roadsides as that of a *Bassariscus* reported by Fisher (1933). Further losses in Idaho were reported by Sperry (1933). He found 763 lagomorphs killed in 685 miles in one locality and 598 in 50 miles near Boise. In his "Feathers and Fur on the Turnpike" (1938) J. R. Simmons reported ten years of observations in New England. Fifty-one species of birds and fifteen of mammals were killed by cars with the peak kill coming between July 15 and Aug. 15. Scott (1938) in an intensive study in Iowa found an average of .429 animals killed per mile of rural paved highway. He noted 57 species killed during one year of observation. There was a direct relationship to weather and to roadside cover. He noted that the average length of time when the animal remained identifiable was four days. In New Mexico, Knobloch (1939) found in summer the loss on concrete was 4.1 animals per mile, on gravel .45 per mile. Martin (1939) reported losses in Michigan amounting to approximately 1000 deer

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per year with proportionately heavy losses to rabbits, pheasants, and fox squirrels. Dickerson (1939) found the losses to animals three times greater west of the Mississippi River than east of it. For Wisconsin, Hein (1941) has reported on a kill record for 27 miles in Sauk Co. and here the loss was greatest during the summer months, averaging 22 per mile for a ten month period. Bugbee (1945) in Kansas found the losses of snakes greater on asphalt pavements than on gravel roads.

With the increased construction of super highways and faster driving, highway kill of wildlife can be expected to go up. This may be counteracted somewhat by the greater width and lowered attractiveness of the roads to wild animals through the use of concrete and other hard surfaces. But where highways of any kind traverse desirable wildlife habitats the losses can become great.

During the three year study in Nebraska the bulk of travel was in the central part of the State from Valentine on the north to Grand Island on the south. Each victim that was not recognized at once as to species as it was passed was collected and identified. Many valuable specimens were collected for mounting, analysis of crop contents, parasites, etc. Because of the time consumed, data concerning the type of road surface, land use, etc. were recorded only for game birds and mammals, excluding the lagomorphs.

THE KILL

More than a hundred species and a total of 6723 individuals of animals other than invertebrates were noted. Amphibia made up 17.4%. Of these, toads of at least two species were most commonly killed, and made up 14.5% of the total. Reptilia included 18.2% of the highway victims. The two most commonly found were the bull snake, making up 5.9%, and the garter snake, 4.7% of the total. Turtles made up 4.0% and half of these were box turtles.

Birds, including 56 species, made up 23.5% of the casualties. Of these only six species, which habitually feed along roadsides or fly low across the roads, were found in excess of 1%. Pheasants made up 5.7% of the casualties, burrowing owls 1.3%, red-headed woodpeckers 2.7%, prairie horned lark 1.6%, English sparrow 4.0% and western meadowlark 1.3%.

Of the mammals, 29 species made up 40.5% of the total and the bulk was lagomorphs, 25.1%. Seven species were noted in excess of 100 individuals; domestic cat, 3.4%; striped skunk, 1.1%; 13-lined ground squirrel, 2.6%; kangaroo rat, 4.7%; cottontails, 9.1%; black-tailed jackrabbits, 6.1%; and white-tailed jackrabbits 2.3%. To the rabbits should be added unidentified rabbit remains totaling 7.3%.

Twenty-six species made up 89.8% of the total kill while the remaining 75 species accounted for only 10.2%. The list of highway victims was as follows: tiger salamander 99, frogs 105, toads 977, sand lizards 95, bullsnake 398, blue racer 62, garter snake 320, hog-nosed snake 78, king snake 1, prairie rattlesnake 9, snapping turtle 5, box turtle 132, painted turtle 15, soft-shelled turtle 1, mallard 1, green-winged teal 1, blue-winged teal 1, redhead duck 1, red-tailed hawk 1, Swainson hawk 5, American rough-legged hawk 2, golden eagle 1, marsh

hawk 2, sparrow hawk 17, prairie falcon 1, prairie chicken 4, sharp-tailed grouse 19, chukar partridge 1, domestic turkey 10, guinea fowl 10, ring-necked pheasant 386, sora 1, coot 4, upland plover 1, mourning dove 55, domestic pigeon 10, yellow-billed cuckoo 27, black-billed cuckoo 9, barn owl 3, screech owl 19, burrowing owl 93, short-eared owl 5, night hawk 11, flicker 22, red-shafted flicker 1, red-headed woodpecker 183, eastern kingbird 54, Arkansas kingbird 12, prairie horned lark 109, bank swallow 14, barn swallow 17, cliff swallow 2, magpie 1, blue jay 6, crow 12, brown thrasher 15, robin 9, shrike 11, English sparrow 265, western meadowlark 95, redwing 11, orchard oriole 1, Baltimore oriole 7, bronzed grackle 14, cowbird 2, common goldfinch 1, lark bunting 9, vesper sparrow 1, lark sparrow 7, field sparrow 1, Lapland longspur 1, opossum 5, common mole 1, raccoon 2, weasel 2, spotted skunk 43, striped skunk 74, badger 2, dog 49, coyote 2, cat 228, Franklin ground squirrel 16, black-tailed prairie dog 1, 13-lined ground squirrel 175, western chipmunk 8, fox squirrel 48, pocket mouse 5, kangaroo rat 316, muskrat 38, Norway rat 10, white-tailed jack rabbit 167, black-tailed jack rabbit 413, cottontail 618, pig 6, cow 1, horse 1.

THE KILL AND HIGHWAY USE

There was considerable difference in the ratio of highway usage by motorists and the highway mortalities from year to year. The total mileage for the writer each year was 1941, 29,850; 1942, 23,680; 1943, 21,485. This was a ratio of 100: 79.3: 72.1. The ratio of observed casualties was 1941, 100; 1942, 109; 1943, 46. Information furnished by the State Department of Roads and Irrigation indicated an over all State highway usage ratio of 1941, 100; 1942, 83; 1943, 72. Correcting the ratio of kill based upon highway use indicates the following: 1941, 100; 1942, 137; 1943, 64. Other observations by the writer indicated a general increase of wildlife in 1942 over 1941 and a general decrease in 1943. This is borne out by highway mortality which showed a gain of 37% in wildlife populations in 1942 and a drop of 54% in 1943, to a level 36% below that of 1941.

Table 1 indicates the number of dead animals along the highways per one hundred miles of driving. The average in 1941 was 9.6 animals per 100 miles. This increased to 12.1 in 1942 and decreased to 5.7 in 1943. The three year average highway loss was 9.1 animals per 100 miles, with a July peak of 22.0. The increase in loss of animals was 26% in 1942 compared to a 17% reduction in highway travel. This could be construed to mean an increase in wildlife of nearly 43% (by corrected

TABLE 1.—COMPARISON OF HIGHWAY MORTALITIES IN CENTRAL NEBRASKA FOR THE PERIOD MARCH 1941 THROUGH MARCH 1944. FIGURES INDICATE THE DEAD ANIMALS PER HUNDRED MILES OF DRIVING

Month	1941	1942	1943	1944	Average Kill
January....		2.1	1.2	2.0	1.8
February...		1.4	2.5	1.0	1.6
March	6.5	9.9	3.0	1.1	5.1
April.....	3.3	3.1	6.6		4.3
May.....	6.1	6.4	7.0		6.5
June.....	9.3	14.0	6.3		9.9
July.....	27.1	26.6	12.3		22.0
August.....	15.2	21.6	12.1		16.3
September..	16.3	32.2	5.0		17.8
October	5.6	7.4	4.0		5.7
November..	2.1	5.8	1.9		3.3
December .	4.4	1.2	1.8		2.5
Average....	9.6	12.1	5.7	1.4	9.1

highway kill ratio above it was 37%). In 1943 the average kill was 40% less than that of 1941 and the highway use was down 28%. This would mean an animal population approximately 12% less than that in 1941 (Corrected highway kill ratio above would make it appear 36% less.) Determining the actual increases or decreases in wildlife populations from highway mortalities would necessitate further study, but it is evident that the losses are proportional to the population densities.

SEASONAL HIGHWAY LOSSES

A species may be present on the highways for several months, during its normal periods of activity, and at no time make up a large percentage of the mortality. Other species during certain months, or even weeks, may have a period of extensive movement and make up a large part of the mortality for that month or period. This relationship between time and space for twenty-four of the commonest victims was as follows: 66.0% of the frogs were killed in August, but made up only 6.0% of the highway losses for that month. In March 94.0% of the tiger salamanders were found, and this made up 21.5% of the highway losses. In August 29.8% of the toad losses for the year occurred, and they made up 25.3% of the highway victims. Of the lizard losses 45.2% occurred in June, making up 7.5% of the losses for that month. In October 24.2% of the blue racers were killed, but these made up only 3.5% of the losses. The hog-nosed snake had 29.5% of its losses in September, but made up only 2.3% of the victims then. Although only 3.7% of the garter snakes were killed in October, they made up 16.6% of the victims for that month. The bullsnake ratios were more balanced for 25.1% of the year's losses in May made up 21.7% of the animal victims. The box turtle suffered heavy losses in June, 37.1% of the year's kill, but made up only 8.6% of the victims for that month. In July 56.3% of the mourning dove losses occurred, making up 1.3% of the kill. In August 38.7% of the burrowing owl losses occurred, making up 3.1% of the kill. Pheasants had 8.5% of their losses in April, 14.9% of the kill for that month. In August 31.1% of the red-headed woodpecker losses came, making up 5.0% of the kill. Also in August the eastern kingbird sustained 27.7% of its losses, 1.3% of the victims. Eighteen percent of the horned lark losses were in March and made up 4.5% of the kill. July was the month of greatest loss to the meadowlark, 44.2%, but they made up only 1.8% of the loss for that month. Also in July 63.4% of the English sparrows were downed, making 7.5% of July's losses. Among the mammals 9.4% of the striped skunks were killed in April, making up 3.1% of April's victims. Seven percent of the cats were killed in December including 16.1% of the losses. Also seven percent of the kangaroo rats were killed in January, but they included 23.0% of the kill. In April 8.5% of the cottontails were killed, making up 24.0% of April's victims. Also in April 10.8% of the year's kill of black-tailed jack rabbits made up 20.0% of April losses. In February the white-tailed jack rabbit sustained 6.5% of its losses, which was 14.2% of the February victims. In July 64.6% of the 13-lined ground

squirrels were killed, making up 5.0% of the loss. The 24 species made up 80.8% of the year's mortality and only during September, November and December did their losses constitute less than 70% of the monthly total.

July was probably the month of greatest animal abundance, altho this was not always reflected in tallies of living individuals. It was, however, indicated by highway victims which were most numerous in this month. Of all of the amphibia recorded 41.0% were crushed in July; 25.0% of the reptiles; 37.4% of the birds; and 27.0% of the mammals.

The percentage of the year's losses that occurred each month for each species constituted essentially a graph of its seasonal activity and population density. Frogs appeared on the highways in May after having left their hibernacula and during the mating season. They appeared again in greater numbers in August after having completed their aquatic development. At this time they were leaving ponds that were drying up and were seeking other water. The tiger salamander did not appear on roads in numbers except in March when they were leaving their hibernacula. Toads appeared on the highways in May, reached a peak of abundance in July and disappeared from them in October. Both the spadefoot and American toads migrated in great numbers from ponds in July. On favorable days and in favorable weather they could be seen hopping along black-top or gravel roads by the thousands. In one location on July 18, 1942, five miles south of Basset a band of small spadefoot toads was hopping along a gravel road. They were moving west and passed the observer at a rate of a hundred a minute. The weather was warm, partly cloudy, and the time about noon. The count was continued for twenty minutes and during this time the toads left the road and took to grass beside it when the sun came out; returning to the road when the sun was obscured by a cloud. The total extent of this migration was not determined. In July 47.7% of the highway kills occurred.

Heaviest losses to sand lizards of several species occurred in June. They were unexplainably absent from the highways regularly traveled by the author in September, appearing again in small numbers in October. Blue racer snakes appeared in May and showed peaks of losses in June and October. The hog-nosed snake appeared in May and it too had two periods of heavy loss, July and September. The gartersnakes appeared a month earlier, but showed the same pattern of loss as the hog-nosed snakes. Bullsnake losses were fairly uniform from June thru October. Peak losses for this species came in May. Snakes came to black-top surfaced highways on cool sunny spring or fall mornings to warm themselves. This accounted for heavy losses in May and October. Box turtles appeared on the highways in May, reached a peak of abundance in June and disappeared from the roads in September.

Bird species had losses commensurate with their migratory habits and population patterns. The mourning dove losses started in May, reached a peak in July and stopped in October when the bulk of the population had migrated. Burrowing owl remains did not appear until June and 47.3% of the losses

occurred in July. They no longer appeared on the highways after September. Ring-necked pheasant losses occurred every month of the year with peak losses in July and August. Red-headed woodpecker victims were found from May thru September and greatest numbers were present in July. Another summer resident, the eastern kingbird had the same loss pattern. Horned larks were killed every month but November, and peak losses were in March and July. Meadowlarks were victims over a seven month period, from March thru September. These, too, were most commonly found in July. Although English sparrows were permanent residents they were not killed on the highways until May thru September. Peak losses were in July.

Among the mammals the numbers of highway victims varied between seasons and among species. The striped skunk appeared every month but February. Domestic cats were present every month with low peaks of loss in March and July. The kangaroo rat suffered its greatest losses in July, but was present every month. Cottontails were also most commonly killed in July and the same was true of black-tailed and white-tailed jackrabbits. The 13-lined ground squirrel left its hibernacula in April and losses began then. They were greatest in July and disappeared during October as the mammals returned to hibernation.

HIGHWAY LOSSES AND THE AGE OF THE VICTIMS

During the period when highway victims were being recorded the numbers of living mourning doves, ring-necked pheasants, horned larks and meadowlarks along the highways were also counted. The highway losses did not seem to be closely related with the visible populations, but appeared to be more definitely related to the feeding habits of the birds or to their age and experience. Actually the highway kill was related to both the population density and the experience of the individuals. Birds inexperienced in the speed of approach of vehicles and in the judgement of these speeds were more apt to be killed. This is borne out by Table 2, in which the percentages of total kill are compared with the percentages of the total living population seen along

TABLE 2.—A COMPARISON OF THE PERCENTAGE OF HIGHWAY VICTIMS WITH THAT OF THE LIVING INDIVIDUALS SEEN EACH MONTH ALONG ROADSIDES IN NEBRASKA, 1941 THRU 1943.

Month	Mourning Dove		Pheasant		Horned Lark		Meadow Lark	
	Percent of Kill	Percent of Living	Percent of Kill	Percent of Living	Percent of Kill	Percent of Living	Percent of Kill	Percent of Living
January			1.3	21.2	.9	4.0		.2
February			1.5	14.9	2.7	27.0		.2
March		.01	5.2	12.2	18.3	22.2	2.1	2.5
April		3.6	8.5	6.6	1.3	5.8	4.2	13.3
May	9.0	12.0	10.3	2.1	3.6	3.4	4.2	9.1
June	10.9	15.6	3.6	1.4	9.2	9.0	7.3	14.4
July	56.3	25.5	26.4	1.9	40.0	9.6	44.2	18.0
August	16.3	32.8	20.4	3.5	10.0	5.7	22.1	13.5
September	3.6	10.1	18.4	4.2	9.2	2.6	15.7	14.3
October	3.6	.1	1.8	4.5	3.6	5.8		13.5
November			2.0	7.4		2.7		.5
December			.3	20.0	.9	1.7		.05

the roadsides. March was the month of greatest snow and most severe weather for Nebraska. During this month 22.2% of the year's Horned Lark roadside population was counted. These birds habitually gathered in large flocks to feed and enjoy the warmth along the roads and roadsides where graders had swept off the snow and ice. Because of this habit 18.3% of the total kill was suffered in this month.

The loss of inexperienced and young birds was evident in summer months following the peak of the nesting season. During July and August 58.3% of the mourning doves were tallied, but 72.6% of the season's kill came in these months. Peak hatch of pheasants usually occurred in June, but in July, August and September only 9.6% of the year's count of live birds was recorded while 65.2% of the highway losses appeared then. The horned lark was an early nester and 24.3% of the total birds were seen in June, July and August. During this period 59.2% of the highway losses were recorded. The situation was similar for the meadowlark; 45.8% of the year's tally of living individuals were seen in July, August and September, but during these months 82% of the highway losses were recorded.

Highway losses due to inexperienced animals as well as an increasing population is further borne out by a comparison of the monthly highway traffic and monthly losses. January travel was 76.7% of the yearly average and from this seasonal low the amount of travel increased to 123.5% of average in August. Highway losses showed a similar but more abrupt rise from a low in February of 17.5% of average to 241.0% of average in July. If highway kills were directly proportional to travel the losses would be expected to follow more closely the trend of traffic. Instead the losses rose precipitously with the appearance of inexperienced individuals, with a maximum July loss almost fourteen times as great as the February minimum, while August traffic was only 1.6 times as great as the minimum of January.

HIGHWAY MORTALITY AND ROAD SURFACE

In 1942 there were approximately 101,000 miles of roads in Nebraska. Of these, sand or dirt roads made up 80.0%, concrete 1.2%, gravel 15.7%, and black-top or macadam 2.6%. The road surfaces traveled by the author were not in the same proportion as that of the State. They were more nearly: concrete 2.0%, gravel 44%, black-top 52.0% and dirt or sand 2.0%. Only a small percentage of animals would be expected to be killed on sand or dirt roads, because of the reduced velocity of vehicles. Conversely, mortality on concrete highways would be great because of high vehicle velocity. Both gravel and black-top surfaced roads were attractive to birds because of available grit. In addition vehicle speed on these surfaces was great.

For game birds and mammals, exclusive of rabbits, records were kept of the road surface at the site of each kill. A total of 550 individuals of 17 game species were tallied in this way. Of these, 361 were pheasants. Six other species, striped skunk, muskrat, mourning dove, fox squirrel, spotted skunk, and sharp-tailed grouse included more than ten individuals. The bulk of the muskrats counted were killed at a small

pond bordered by a concrete highway. Sharp-tailed grouse live mainly in sandhill grasslands traversed only by sand, gravel and black-top surfaced roads and 72.7% were killed on black-top, the remainder on gravel roads. If we eliminate these two species and make corrections as to the amount of driving the writer made on each type of road we have the following correlation:

	Relative mortality on;			
Species	Concrete	Black-top	Gravel	Dirt or Sand
Ring-necked pheasant	100	20	19	14
Striped skunk.....	100	3.8	2.3	3.7
Mourning dove.....	100	21	45	0
Fox squirrel.....	100	7.3	11.5	0
Spotted skunk.....	100	3	2.5	0

For each one per cent of the total mileage traveled over concrete roads 4.6% of the total pheasant kill was counted, whereas for each one per cent of travel on gravel roads .87% of the total pheasant kill was noted. Of the total mileage traveled, 16.3% of the game animals were found dead along concrete roads totaling 2.0% of the travel, 39.4% along the black-top making up 44% of the travel, 43.0% along gravel roads making up 52% of the travel, and 1.1% along the dirt roads making up 2.0% of the total travel. Apparently an animal crossing concrete has one-eighth the chance of survival as it would crossing other types of road surfaces.

HIGHWAY MORTALITY AND SOIL TYPE

As a matter of convenience soil types were divided into two major groups; sandhill or sand lands, mainly native prairie, an uncultivated grazing area; and hardlands or cultivated soils of less porous composition. Observations in the two areas were approximately equal in extent and from this it appeared that the more varied soils and land uses in the hardlands produced a larger number of game animals.

A total of 336 game animals were found dead in hard land soil areas and 175 in the sandhill areas. Two hundred pheasants were found in hard lands and 126 in the sandhills. Striped skunks, mourning doves, fox squirrels, and spotted skunks were all more numerous in the cultivated areas than in the sandhills. The comparative figures were respectively: striped skunk 36 to 6, mourning dove 30 to 5, fox squirrel 23 to 5, and spotted skunk 10 to 7. Sharp-tailed grouse and prairie chickens were found dead only in the sandhill areas.

HIGHWAY MORTALITY AND LAND USE

The use of highway mortalities as a tool indicating distribution and habitat usage of birds and mammals has potentialities. It may be considered a random sample of those species that cross open areas and a survey of highway kills can be conducted by observers untrained in other more involved methods of wildlife tallying.

The numbers of highway killed individuals as related to cover or land usage on either side of the road was recorded for 17 game species. Here the method was to list the individual once if the same cover occurred on both sides of the road, i.e., corn, or two or more times if the cover varied, i.e., a farmyard, grove, and pasture. This method penalizes data where roads traverse large

blocks of uniform cover, as the corn growing areas, and magnifies the importance of smaller units of cover. Grouping the various cover types is purely a matter of individual preference. For example; in this study railroad right-of-ways were listed separately from other extensive areas of weeds or brush; but, since most right-of-ways were weedy or brushy, it could have been combined with areas of brush. The roads traveled most often were bordered by railroads or native prairie pasture, therefore these two loom high in the ratio of land usage and animal mortality; 12.9% of the kills were along railroad right-of-ways and 30.9% along pastures. The major crop of the river valleys was corn and 17.9% of the victims were found by cornfields. A very small proportion of the area under observation was covered by trees, groves or shelterbelts, yet 9.2% of the kills were adjacent to these. The percentage of game animals found dead near other types of cover were as follows: in towns .3, by farmyards 2.1, native hay meadows 2.0, woody brush, willows, plum, etc. 1.6, marshy river bottom 3.8, areas of weeds 2.0, plowed fields 3.0, barley 3.4, oats .8, wheat .8, grain stubble fields 3.8, alfalfa 1 6, milo maize .3, clover .1, and unidentified small grains 2.2. In localized studies a knowledge of the proportion of the land supporting each type of cover would clarify the positions of wildlife as related to this.

DISCUSSION

During Scott's study in Iowa he traveled over 43 counties. Studies reported from New England by Simmons covered two strips of highway totaling 55 miles, and Hein's report from Wisconsin was on a 27 mile unit of road. Scott's observations in Iowa and those reported here from Nebraska were probably extensive enough to give an overall picture of the loss from a large area. Simmons' and Hein's reports may distort the picture through selection of areas of especially heavy kill. Table 3 compares the data from these four regions. The material from other authors has been arranged to show the monthly kill per one hundred miles of highway. In Nebraska the average yearly loss per 100 miles was 9.1 vertebrates, in Iowa it was 42.9, in New England it was 70.5 and based upon the small sample in Wisconsin it was 249.9.

TABLE 3.—A COMPARISON OF THE AVERAGE RATE OF HIGHWAY LOSSES TO WILDLIFE IN NEW ENGLAND, IOWA, WISCONSIN, AND NEBRASKA. FIGURES GIVEN ARE THE AVERAGE NUMBER OF ANIMALS FOUND DEAD PER 100 MILES OF HIGHWAY

Month	New England	Iowa	Wisconsin	Nebraska
January....	3.6	26.3		1.8
February...	3.6	72.6		1.6
March	18.1	53.8	122.2	5.1
April.....	52.7	68.4	274.0	4.3
May.....	87.2	48.4	207.4	6.5
June.....	140.0	36.2	333.3	9.9
July.....	174.5	7.1	425.8	22.0
August.....	180.0	17.3	277.7	16.3
September..	87.2	4.4	403.7	17.8
October	58.1	13.0	274.0	5.7
November..	34.5	7.2	59.2	3.3
December .	7.2	29.8	122.2	2.5
Average....	70.5	42.9	249.9	9.1

Scott determined that the animal remains were recognizable for approximately four days. Using the formula: Average Number of Animals per Mile X (Number of Days in Year ÷ 4) = Yearly Loss per Mile, he felt that fairly accurate losses on a given stretch of improved road could be obtained. He showed a loss of .024 pheasants per

mile, corrected to 2.22 per mile per year. Using this method for Nebraska data the loss of pheasants was .42 per mile per year. As there were more than 20,000 miles of improved roads in the State a highway loss of nearly 9,000 birds is indicated. In Nebraska one of every 2.2 days was spent in the field or driving, and rarely were the same dead animals encountered, even though the same piece of road was covered every 2.2 days. This indicated about half the survival time of a carcass as shown by Scott.

The Nebraska data appear to indicate certain conditions affecting the magnitude of highway losses. These may be expressed as follows: 1. Highway kill is inversely proportional to the experience of wildlife with fast moving vehicles. 2. Highway losses are directly proportional to wildlife populations adjacent to roads. 3. Highway losses are related to the habits of each wildlife species. 4. Highway losses are more closely related to the age composition and density of wildlife populations than to the amount of traffic. 5. Highway losses are directly proportional to the degree of road improvement; or thereby directly proportional to the speed of traffic. 6. Highway kills seem to be directly proportional to the interspersion of soil types. 7. Highway kills are directly proportional to the density of the adjoining cover.

SUMMARY

1. During the period January 1941 thru April 1944, 6723 animals were counted as highway victims along 77,000 miles of driving on Nebraska roads. More than a hundred species were noted and of these amphibia made up 17.4%, reptilia 18.2%, birds 23.5% and mammals 40.5% of the total kill.

2. Because these were war years, the amount of highway travel decreased, but the 1942 kill increased showing an increase in the general animal populations.

3. The three year average highway loss was 9.1 animals per 100 miles.

4. Twenty-six species made up 88.8% of the total kill. Toads, lagomorphs, bullsnakes, and pheasants suffered the greatest losses.

5. July was the month during which the greatest number of losses occurred. This was related to the increased numbers of new inexperienced animals as well as to the increase in highway use by vacationing motorists.

6. Each of 24 species most commonly found on the highways suffered losses in relation to their seasonal activities.

7. Heaviest losses per hundred miles of highway occurred along concrete highways where an animal appeared to have one-eighth the chance of survival that it had crossing other types of road surfaces.

8. Losses were heaviest along roads traversing hardland cultivated soils. More victims were seen along roads bordered by pastures, corn, and railroad right-of-ways in that order, since it was through this type of cover that the writer traveled most often.

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REVIEWS

EDITOR'S NOTE: It has been suggested to the editor that our Review section would be strengthened and varied if, on occasion, an important publication were given space for two or more reviews. The value of such treatment is, of course, greatest for publications upon which sharply divergent views are likely to be held. We shall appreciate hearing from members whether they feel that the value of such treatment, tried in this issue for the first time, justifies the additional space it takes.

Relationships and Dynamics of Balanced and Unbalanced Fish Populations. By H. S. Swingle. Bulletin No. 274. June 1950. 74 pp. Agricultural Experiment Station of the Alabama Polytechnic Institute. Auburn, Alabama.

The data for 89 fish populations recovered from ponds at the Alabama Agricultural Experiment Station between December 1939 and October 1949 are listed and compared. Except for four ponds that were treated with rotenone, the censuses were determined by draining the ponds and sorting, counting, and weighing the fish.

Such a mass of data may be of considerable value for comparison with similar data collected in other parts of the country. However, much important information is lacking in nearly all cases. Stocking rates and the sizes of fish used in stocking are not listed for any pond nor are the periods of time that any population was confined to a particular pond given. In only 18 of the 55 "balanced" populations and in only 10 of the 34 "unbalanced" populations are the sizes of the ponds indicated. Furthermore, the data given for the ponds are not comparable in all instances. Whenever the size of the pond is given the total recovered weight for the entire population is listed, whereas whenever the size of the pond is omitted the data on the fish recovered is listed in pounds of fish per acre. In presenting data of this nature it is desirable that the methods and procedures be listed so that the reader might be able to make valid comparisons with work done in other areas.

For analysis the populations were divided into two groups—balanced and unbalanced. Balanced populations were defined as "those capable of producing satisfactory annual crops of harvestable fish." The choice of the word balance in this instance is unfortunate. Balance, as used by ecologists, usually means the mutually beneficial adjustment between animals and their food supply. In that sense any exact adjustment is very seldom reached, and if it is reached, it is probably maintained for only a relatively short period of time. Perhaps the use of the term "satisfactory" or "unsatisfactory" for fishing purposes, or some other self-explanatory phrase would have been better than giving a new, and poorly justified, meaning to a word that has already become well established in the literature.

When any fish population is censused at the end of any period of time by draining the pond, or any other method for that matter, all that can be measured is that portion of the standing crop that is recovered. None of the dynamics of the population—the various occurrences that caused the population to have the particular form and composition it had when censused—can be studied at that time. The

only part that can be studied is the sum total of the effects of those causes on the population. To study the dynamics of any animal community it is imperative that continuous observations be made. From the way the data are presented in the Tables of the Appendix it is apparent that the author saw the populations only on the particular occasion listed. However, in some cases the data may be for the same population recovered from the same pond for several successive years as indicated in Tables 38-B, 39-B, and 40-B. Those data are all for ponds 1.3 acres in extent and represent populations recovered in December 1939, December 1940, and December 1941 respectively. Similarly, the data in Tables 32-U, 33-U, and 34-U may represent the same population recovered on three successive years.

The terms predator-prey ratio, percentage composition of the population by species, and the relative abundance of fish of harvestable size are accepted by fisheries workers and there is little to be gained by obscuring them under such terms as the F/C ratio, the E value, and the A value respectively. Such abbreviations may be all right in the text after suitable definition but they appear to be somewhat out of place in the table of contents and as major paragraph or section headings.

The tremendous amount of overlap that occurs when various items in the "balanced" and "unbalanced" populations are compared serves to show that fish populations in general do not follow any set pattern of internal composition. For instance, the F/C ratio (prey/predator ratio) in 24 of the 34 unbalanced populations fell within the range of those populations classified as balanced. Similarly, 17 of the 31 Y/C ratios (forage fish small enough to be eaten by average sized predators/total weight of predators) figured for the unbalanced populations fell within the range of the balanced. The best single standard the author used was the A_T or total availability value (percentage of the total weight made up of fish of harvestable size). For that item only six of the 34 unbalanced ponds fell within the range of the balanced populations. This is just another way of saying that the best criterion for a balanced fish population is one that has the most large fish in it for the angler to catch. Or perhaps it is a more obscure way of saying that the fish in a stunted or overcrowded population do not grow so large as those in a population that is adequately cropped and thus provides good fishing. In any event it is apparent that no one criterion as simple as the three just mentioned can be used as an accurate measure of the relative size of the harvestable fish population in any body of water.—LOUIS A. KRUMHOLZ.

Relationships and Dynamics of Balanced and Unbalanced Fish Populations. By H. S. Swingle. Bulletin No. 274. June 1950. 74 pp. Agricultural Experiment Station of the Alabama Polytechnic Institute, Auburn, Alabama.

After reviewing briefly the methods used in sampling fish populations, Swingle states:

> ". . . it is evident that the fisheries technician can now, with the various methods at his disposal, determine more or less accurately the species composition of a particular population. He appears, however, somewhat at a loss as to just what to do with this information, how it should be reported, and how to interpret it."

Fisheries workers will respond to the second sentence with a loud "Amen." They have collected an abundance of survey data, including information on fish populations, but the interpretation and use of these data have frequently failed to materialize.

This publication presents methods of interpreting the data, as applied to fish ponds. It is based on an examination of 89 fish populations. The publication is of special interest both because it concerns a "bottleneck" in fisheries work, and because it is written by an individual whose contributions to the farm fish pond program have exceeded greatly those of any other fisheries worker. Interestingly enough, the question of how to manage the farm pond, simplest and most manageable fishing unit, is still a controversial one.

A major objective in pond management is to have a balanced fish population. Most ecologists probably think of "balance" as a relationship between animals and their food which is mutually beneficial. Swingle refers to "balance" as a condition where the fish "populations yield, year after year, crops of harvestable

fish that are satisfactory in amount when the basic fertilities of the bodies of water containing these populations are considered."

If these two interpretations of balance tend to be dissimilar, the reason for this difference is easily found. The practical fisheries worker is interested not in the population *per se*, but in the harvesting of the crop. His viewpoint differs in this respect from the viewpoint of those ecologists whose interests are limited simply to plant or animal communities as such. As a fisheries worker, I find that Swingle's definition of balance is quite acceptable.

The publication states, quite correctly, that unbalance is commonly "due to overcrowding —the survival of so many individuals that none can grow to a size satisfactory for harvesting." Preventing over-population is a major problem in lakes and ponds.

Swingle analyses the populations by use of several ratios and factors. The first of these is the F/C ratio, where the "C" represents the species which normally live on other fish species, and "F" represents species which normally live on plants, plankton, crustacea, and insects. In the common bass-bluegill combination, the bass is the "C" species and the bluegill is the "F" species. In this ratio, as in the other ratios and factors, the unit employed is "pounds" of fish, not numbers of fish. The study indicates that an F/C ratio of 3.0 to 6.0 is preferable.

The next ratio discussed is the Y/C ratio where the "Y" represents the pounds of forage fish which are small enough to be eaten by the average-sized adults of the carnivore ("C") species. Here the suggested desirable ratio ranges from 1.0 to 3.0.

Next considered is the A_t value, which is the "percentage of the total weight of a fish population composed of fish of a harvestable size." The preferable value is between 65 and 85. This value must fluctuate within the limits of 33 to 90 if the pond is to remain in balance.

Further values are discussed, dealing chiefly with individual species, and with the distribution of adult, intermediate and young sizes in the population.

As might be expected, a single value, taken independently, may be misleading. For example, the F/C ratio, or the Y/C ratio, were satisfactory in some of the unbalanced populations. The publication gives no single, simple, fool-proof indicator which will tell at a glance whether or not all is well, or not well, in the fish pond. We would be amazed if such indicator were found.

Presumably, most of the 89 populations were studied only once—at the time the pond was drained or the population was killed by use of rotenone. This might be a bit disconcerting to the individual who realizes that populations are changing constantly. However, a single look at each of the 89 populations is probably more informative than the continual study of a single population, or of several populations.

The veteran fish pond worker, if he maintains an open mind, and an analytical point of view, can probably seine some fish from the pond and decide, on the basis of previous experience, whether or not the pond is in balance, and can prescribe remedies for unbalance. However, the problem of passing on this ability to the embryo fisheries worker is a perplexing one. It is in this connection that the bulletin is extremely valuable. The beginner is given something tangible and concrete to help him in his analysis of the fish population.

To my way of thinking, this bulletin is another of Swingle's many important contributions to fish management.—R. W. ESCHMEYER.

Wildlife Management. By Ira N. Gabrielson. The Macmillan Company, New York. 1951. 274 pp., 40 pls., 9 tables. $4.50.

This book is the third and culminating volume recapitulating the ideas and observations of a senior statesman in wildlife administration. The first two volumes (*Wildlife Conservation*, 1941, and *Wildlife Refuges*, 1943) covered some of the same ground with different points of emphasis. None of the three are technical books in the sense of presenting specific or detailed information on wildlife or its management, but rather they are generalized, highly readable summaries of the problems and answers in the field of administration. This third volume, in fact, might better have been titled "Wildlife Administration" for that is the aspect of management with which it deals best.

The thirteen chapters cover all the broad phases of the field, from research to public relations. Strongest of these are the chapters on

education, sportsmanship, administration and "Can public hunting and fishing be maintained?" One can detect in these chapters particularly the keen appreciation of the experienced administrator for the proper synthesis of technical knowledge and political know-how, of field procedure and conference room procedure. Dr. Gabrielson pulls no punches in analyzing the part (often highly inhibitory) played by organized sportsmen in the administration of fish and game, yet he freely acknowledges the beneficial support that these groups have given on many important matters. Likewise he chides the technicians for being academic and overmeticulous in such matters as conducting censuses or drawing cover maps (which should be only means to better management, not ends in themselves), while at the same time the absolute necessity of technical knowledge on game is fully granted. There is a refreshing candor in the complete independence with which Gabe evaluates the good and the bad in wildlife management as it is practiced in this country today.

There are many minor points in the book with which the reviewer cannot agree. Some of these are merely incomplete analyses of problems; others seem to reflect personal bias or weighted opinion. Thus, in the discussion of hunting controls the idea is emphasized that organized sportsmen generally are clamoring unjustifiably for longer seasons and bigger bag limits. This certainly applies to waterfowl, with which Dr. Gabrielson has had the most experience, but the converse is true of many types of resident game which commonly are overprotected by sportsman pressure (e.g. rabbits, pheasants, deer). The desirable functions of refuges are well presented but their limitations are only incompletely defined. Small refuges for pheasants are endorsed despite the complete lack of proof that they are needed when cocks only are shot. Speaking of ruffed grouse refuges, the author states: "Certainly, unless the terrain included in a refuge is made more suitable for the rather specialized needs of these birds, it is not probable that a single extra bird will be produced." (p. 112). He does not ask the corollary question, "If the habitat is improved, why have a refuge?" Big game refuges are defended when actually most states are trying to abolish them, except those protecting rare species. As in the case of hunting controls, the needs of waterfowl for more and better refuges have been overextended in application to resident game. The shooting preserve law as it applies to liberated pheasants is endorsed despite much evidence that it is based on a biological falsehood (100 birds released does *not* mean 100 birds added to the wild population). The need for predator control is defended by attacking the "balance of nature" concept, which has long since become a straw man. Most critics of excessive control have ceased to talk about such balance but have been asking, "Does it produce more than it destroys?" Control of large predators as a cause of deer irruption is not discussed at all.

Despite these shortcomings, "Wildlife Management" is a book that should be owned by every technician, administrator and sportsman. Dr. Gabrielson is to be congratulated for recording so faithfully his wide experience in the wildlife field.—A. STARKER LEOPOLD.

Ring-necked Pheasant in Missouri, by Donald M. Christisen; Conservation Commission, Pittman-Robertson Program, State of Missouri; May, 1951, pp. 66, photos, tables and figures, mimeo.

This is a final report on a 3-3/4 year project "to evaluate the current distribution and abundance of the pheasant in Missouri and to summarize its history." Despite the handicap of meager populations the author has put together a report that will be interesting and profitable to pheasant workers.

Evidently written for the layman, there is a review of the well-known history of the pheasant in the United States, and some new material on the introduction and restocking in Missouri. Of most value to the technician are the analysis of Missouri conditions and the account of local distribution. Particularly significant is the relationship between pheasant distribution and soil fertility, which he relates in part to sources of alluvial materials. Habitats along rivers originating outside the state are superior to floodplains of local streams.

Many game managers will question the evident optimism with which Christisen views habitat improvement for Missouri pheasants, but it will be observed that his recommenda-

tions involve sound land-use as well as game management.

The author includes a map of pheasant distribution in the United States adapted from a well-known generalized distribution map (McAtee, The Ring-Necked Pheasant, 1945). Although the detailed break-down of range gives an impression of greater accuracy, close inspection reveals that the adaptation is little if any improved over the original.—FRED H. DALE.

Water—Or Your Life. By Arthur H. Carhart. 1951. J. B. Lippincott Co., Phil. and N. Y. 312 pp. $3.50.

It is probably not unfair to say that the conservationists have discovered water. I may not have come across some of the new books on water conservation, but a half dozen are piled on my desk, all of which have appeared within the past twelve months. First is WATER AND MAN, a compendium subtitled A Study in Ecology, which consists of papers read at a Friends of the Land meeting. Last year also saw publication of THE WATER SEEKERS by Remi A. Nadeau, which relates the history of water development in southern California and Arizona. Somewhat comparable to the latter is the more recent book by Albert N. Williams; entitled THE WATER AND THE POWER; it covers a large geographic area, treating the major rivers of the whole West. In a much more professional manner Frank and Netboy treat national problems of water use in their WATER, LAND, AND PEOPLE. Then there is the three volume report of the President's Water Resources Policy Commission, the first volume of which is probably of more interest to the wildlife manager than anything else mentioned here, not only because it has a chapter on fish and wildlife, but because of the recognition given to wildlife and recreational values throughout the report. By the time you read this, CONSERVATION OF GROUND WATER by Harold Thomas may have appeared. Other publications support the current attention to water, for example the joint study of the National Association of Manufacturers and the Conservation Foundation, which is entitled WATER IN INDUSTRY, and the study of the Public Health Service called WATER POLLUTION IN THE UNITED STATES.

The above publications are mentioned both because I think they should be called to your attention if you have not seen them, and more particularly because a review of Carhart's book should not imply that it is appreciably better than many other things that are currently appearing in this general field. In some ways WATER—OR YOUR LIFE is more about water than some of the other books mentioned, because the author devotes the first four chapters to the use and value of water. The book starts with examples of water shortages throughout the country. Then there are examples of ancient civilizations which, according to the author, disappeared because there wasn't enough productive soil or adequate, usable water. There are chapters on domestic, agricultural, and industrial uses of water—the most factual and to me the most interesting part of the book—and there is a discussion of how the world is getting drier, a discourse in geological proportions that is out of joint with the historical and modern considerations of the remainder of the book.

In subsequent chapters the author seems unable to separate himself from his attitude toward government agencies concerned with the building of water control structures, especially the Bureau of Reclamation and the U. S. Army Engineers. Even a special chapter on the good that comes out of big dams does little to modify the position that their construction is a wholly reckless waste of public funds. This is probably the most concentrated attack upon such work that has so far appeared, at least in trade book form. There are chapters on stream pollution, water law, rain making, and a final challenge for action. Carhart believes that "watershed management should come ahead of such gigantic manipulations as we are undertaking downriver," that Federal duplication should be eliminated, and that "imposition of a 'valley authority' would be a fundamental abandonment of the existing democratic methods of American government." Although he thinks not enough is being done about it, he believes the solution has been outlined by the Natural Resources Task Force of the Hoover Commission, which calls for a Federal Department of Natural Resources.

WATER — OR YOUR LIFE will give the reader a general picture of the vital significance of water in the personal, domestic, agricultural, industrial, and governmental complex of which each of us is a part. There is a foreword by Jay N. Darling, and an index. The wealth of material to which reference is made shows considerable study was undertaken. None of it is documented, and there is no bibliography, no illustrations. The wildlife manager will be particularly interested in the discussion of the pot-hole drainage controversy in South Dakota and occasional comments on recreation. The entire subject of water management, of course, as an integral part of comprehensive land management programs, is of paramount concern to both the wildlife administrator and technician.

From an ecological standpoint, the book overemphasizes a single factor of the environment, as many conservation books do. While we cannot live without water, we cannot live by water alone. The chief criticism that might be leveled at the book is the impression of hasty writing it conveys. While the almost conversational style makes for easy reading, a closer checking of facts and more careful statement of opinions would have resulted in a more dependable job. A few examples may illustrate. At one place (p. 27) is the statement that "every cutting of alfalfa requires some 325,850 gallons of water to grow it." A few pages later (p. 52) there is the statement that "alfalfa takes 1,250,000 gallons per acre per season." While the reader can ponder out the fact that the first figure is on a per acre basis, and the second must be figured on a 3-cutting per year basis, he can only guess that he is right. It is far from certain that the Mayan civilization disintegrated because of "what happened to water as it fell on the uplands of the plateau, the way it escaped as the ability of the soil to hold it and make it serve declined" (p. 36). In view of the explanations offered by conservationists interested in different subjects, one wonders if we shall ever understand what happened to the Mayans. The quotation attributed to the Soil Conservation Service, that "something more than 5,800,000 acres had been drained in the program, of which about 95 percent was carried out in the forty states important as nesting and wintering areas" (p. 121) is actually paraphrased from an address by a government official in no way connected with the Soil Conservation Service. The inference that so much waterfowl habitat has been destroyed is unwarranted, inasmuch as most of this work is tile and open ditch drainage of existing crop and pasture land, with less than one percent of the total being land of any conceivable value to waterfowl. In reference to the Northeast Carhart perpetuates the mistaken idea that "the major reason for such abandonment [of land] was loss of top soil—the direct result of trying to farm slopes where soil could have stood up in grass or forest use, but not under plow." (p. 179). It is now generally recognized that the chief reason for land abandonment was failure of the Northeast to produce agricultural commodities cheap enough to compete with those of the more productive soils of the middle West. The Weather Bureau is said to be in the Department of Agriculture; actually it was transferred to the Department of Commerce more than ten years ago.

In spite of shortcomings, however, WATER —OR YOUR LIFE and the other current books on water serve to emphasize the importance of this resource to the nation and to each of us as individuals. There is a very direct relationship between water and our personal welfare which illustrates forcefully our complete dependence upon natural resources. When, as a nation and as individuals, we fully realize this interrelationship, we shall begin to translate the conservation movement into functioning elements of the mores and economics of our society. Such books are helping us to do this.—EDWARD H. GRAHAM.

Water and Man—A Study in Ecology, Jonathan Forman and Ollie E. Fink, xvi+407 pp., Friends of the Land, Columbus, Ohio, 1950. $4.50.

This book is substantially composed of papers presented at the Eighth Annual Conference on Conservation, Nutrition and Health sponsored by Friends of the Land at Athens, Ohio. Forman and Fink have provided editing, introductions to many of the chapters (speeches), and three of the thirty chapters plus one of three appendices. Any book written by 29 authors of diverse interests and varied literary talents is bound to be spotty. Being

contributions to a conference with the theme, "Water and Man," rather than objective writings of a planned book, it suffers from lack of continuity, gaps of omission and superficial sections among the many able presentations. The sub-title, "A Study in Ecology" is hardly warranted. While many of the topics are approached from an ecological point of view, some are not and the whole is far from being a study.

The annual conferences on Conservation, Nutrition and Health sponsored by Friends of the Land are one of the most worthy functions of this fine organization. FOL has emphasized the vital relationship between natural resource conservation and human health more than most conservation groups and Dr. Forman has been a leader in this work. Several topics in this book bear on this conservation-health tie-up, as: The Importance of Bio-Elements in Our Drinking Water by Dr. Eelie Asbury; Water Borne Diseases by Dr. Morris Scherago; The Role of Water in the Metabolism of Man by Dr. Fred Hitchcock; Moisture in the Air and Human Health and Efficiency by Dr. Clarence A. Mills.

Many of the other authors present valuable papers that help make this volume a useful reference on water conservation. Robert Struble tells the story of the Brandywine Valley Association in Pennsylvania and Bryce Browning that of the Muskingum Conservancy District in Ohio, two of our successful attempts at grass-roots solution of watershed problems.

Wildlife—an important natural resource that is closely related to water conservation—is not included except in one paper by R. V. Truitt called, Food from Our Water Acres. Several problems of importance in aquatic wildlife management are discussed, including drainage, farm ponds and pollution.—FRANK C. EDMINSTER.

Proceedings of the Alaskan Science Conference of the National Academy of Science, National Research Council; Bulletin of the National Research Council, No. 122, Washington, D. C. 216 pp. 1951.

This volume contains abstracts of 85 papers, 5 complete papers and the text of some 20 speeches. As the title indicates the conference covered a wide variety of topics in the biological, physical and social sciences. Both administrators and technicians contributed papers to this conference.

In the first section of the volume the opening address by Governor Gruening is printed in full as well as the talks by the heads of various government departments and one private organization (The Arctic Institute) concerned with Alaska. The following 90 pages contain abstracts of papers dealing with a whole range of research projects from "Geophysical Investigations in the Aleutian Islands," to "Some Salmon Research Problems in Alaska."

Of the papers printed in their entirety the one entitled "The Alaskan Fisheries" by Director Day of the Fish and Wildlife Service and "Forestry in Alaska" by Regional Forester Heintzleman will be of most interest to wildlife managers. The zoology section under biological sciences contains ten abstracts on Alaskan fish and game; however, for the biologist in Alaska or other northern areas, there is pertinent information in a number of papers under other sections.

Of the resolutions adopted by the conference the one of general interest is the plan for holding future conferences and holding them in Alaska when feasible (the 1951 conference is scheduled for Mt. McKinley Park in early September). In the wildlife conservation field the conference recommended designation as wilderness areas certain lands such as critical caribou ranges and waterfowl breeding areas. Another recommendation stressed the need for much more life history work on Alaskan wildlife species.

These *Proceedings* undoubtedly contain the most comprehensive resume of the present status of scientific research in Alaska to be found between the covers of any one volume. It is understood that a number of the papers appearing as abstracts in the *Proceedings* will be published in complete form in *Arctic*, the journal of the Arctic Institute.—W. A. ELKINS, *Fish and Wildlife Service, Juneau, Alaska.*

Mourning Dove Studies in North Carolina. Thomas L. Quay. North Carolina Wildlife Resources Commission, Raleigh, N. C. 1951. 210 pp., frontis. + 15 figs.

A state-wide study of mourning doves was conducted in North Carolina as a Federal Aid project from July 1, 1939 to 1942. These data were gathered by 18 different individuals who were associated with the project at various times, totaling an estimated 13 man-years. The results have been brought together, summarized and interpreted by Mr. Quay in the present publication.

Studies were made of 771 nests, and data on site; incubation and nestling periods were tabulated and found to agree closely with previously published information. A day-long observation of a nest containing eggs noted the fact, which has been recorded several times in the literature, that the male incubates for 8 or 9 hours during the day, from about 8 or 9 a.m. to about 4 or 6 p.m. Another observation of a nest in which the young had just hatched demonstrated quite a different pattern. The female stayed on the nest the entire morning on which the young hatched and 2 days later the male replaced the female in the afternoon. This daily activity rhythm of the male is very important from the standpoint of timing of the "coo count" method of appraising abundance and it would be desirable to obtain more information on the periods, during the breeding cycle, in which the male coos most frequently.

Although most of the nest observations were not followed to completion it was estimated that successful nests of doves in North Carolina were between 45 and 50 percent of total, which agrees closely with published estimates for other parts of the country. Known causes of nest loss were few but were attributable to the elements, fire, sudden cold weather and wind. Predation was suspected in many cases but only two were observed: a blue jay and a brown thrasher pecked holes in eggs. Egg-laying began in March, rose to a sustained peak during April, May and June, declined during July and August, and stopped in September. About 60 percent of the total hatch by nests occurred in April, May and June, and 75 percent by the end of July. No eggs were laid or hatched from October through February. No appreciable difference was noted in egg-laying dates between coastal plain and mountains, bearing out conclusions of Cole that egg laying is correlated with length of day rather than temperature.

Doves examined for presence of pigeon milk showed 20.5 percent were still feeding young in September.

The author felt that the North Carolina study did not develop accurate techniques for estimating annual production since, on the basis of the area method employed, there was an unknown percentage of nests which were not found in each area studied; and even if all nests were found the calculation would be further complicated by such unknowns as adult mortality, length of breeding season per individual dove, juvenile mortality, influence of weather and agricultural conditions, effects of September shooting, etc.

Three successful cage matings and nestings were accomplished between April 8 and August. Five out of six eggs hatched and young raised to 10 to 23 days of age.

About 2,500 doves were banded, including 1,396 adults, 434 juveniles and 520 nestlings. After experimenting with several kinds of traps, including two-celled Potter, large funnel, and pull-string traps, a 24 by 20 by 12 inch funnel trap type designed by William W. Demerritt, who banded over 6,000 doves at Key West, Florida, was adopted.

Of the recoveries, 8 were from out of state (2 to the northward and 6 to the southward). Of those taken to the southward, two were nestlings when banded, indicating that at least some of North Carolina breeding population are migratory. There were 8 in-state recoveries (more than 5 miles from banding station) and 46 returns (within 5 miles of banding station and more than 3 months after banding). Total recoveries and returns were about 2 percent of birds banded, which is slightly less than the overall percentage for this species. No difference of residence status was noted between physiographic regions or between age and sex groups.

The problem of predation by hawks at dove banding stations was pointed out to be real and still largely unsolved.

No segregation of sexes was found in winter flocks but males appeared to outnumber females 162 to 100 in fall and winter.

Differences in breeding populations based on nests found were considered to be unreliable.

Reports from observers indicated a marked decrease of doves in mid-September to virtual disappearance followed by an influx in October coincident with arrival of cold waves. This indicates that the number of permanent resident

doves must be small. The possibility was suggested that much of the mid-winter population is composed of birds drifting northward.

The author expresses very little confidence in the "roadside count" method of appraising dove abundance in so far as this has been practiced in North Carolina because of the large number of variables. Other investigators have recognized these weaknesses and realize that a very large number of sample counts are necessary to balance the variables and make the data statistically valid.

The chief conclusion for management was that there should be no shooting of doves in North Carolina before late October because of the importance of the increment of late nestings to the total population.

It is the impression of the reviewer that Mr. Quay has done an excellent job of bringing together information on the mourning dove not only from observations of the North Carolina investigators but also from the literature. On the basis of this paper it should be possible to plan future investigations on the mourning dove much more intelligently. It should also now be easier to avoid duplication of studies of details about the life history of the species which are now well known, such as the average number of eggs per clutch, the favored types of nesting cover, period of incubation and length of time young stay in the nest. At the same time it makes possible the determination of problems which we know little about for further investigation such as the timing and extent of fall migration by age classes from and through various breeding areas; whether migrant birds coo while passing through an area in spring where they could be confused with nesting birds thus complicating abundance studies; also the timing and frequency of cooing throughout the nesting season to form a better basis for appraisal of abundance of breeding birds.—JOHN W. ALDRICH, *U. S. Fish and Wildlife Service, Washington, D. C.*

Larvae of Insects. By Alvah Peterson. Part I. Lepidoptera and Hymenoptera. 315 pp., 85 plates. 1948. $5.00. Part II. Coleoptera, Diptera, Neuroptera, Siphonaptera, Mecoptera and Trichoptera. 415 pp., 104 plates. 1951. $7.00. Both lithoprinted volumes are cloth bound, 8½ x 11. Purchase from the author at Ohio State University.

Part I includes a general introduction, instruction on collecting, keys to orders and families and explanatory text with figures. The larvae considered in detail are common, important or unusual species of Lepidoptera and plant-infesting Hymenoptera. Part II treats of the orders considered, especially the Coleoptera and Diptera. Included are general discussions of orders, keys to families, family names, descriptions of families, common and important species, with a list of host indices, a glossary and a general index.

To biologists interested in food habits research these two volumes will prove useful. Both the literature and figures of larval insects are widely scattered and are usually found in reports of monographic scope. A study of these two volumes, if only the figures, will apprise the reader how vastly the larvae of insects differ within a family. More than a passing acquaintance must be made if he is to recognize, at times, even the order to which these larvae belong.

The two volumes are excellent reference material. They will prove helpful to the wildlife manager, the student of food habits and naturalists in general. The price will militate against wide usage, but the volumes are a "must" for those concerned with the dietary of vertebrates.—W. J. HAMILTON, JR.

Spurvehøgen, *Accipiter nisus nisus* (L.) (In Danish, with a nine page English summary) by Vagn Holstein. H. Hirschsprungs Forlag, Copenhagen, Denmark. 1950. 150 pp. 22 figs. Danish kroner 14.00 (=$2.00).

For North American students of birds-of-prey this comprehensive treatise on the biology of the European sparrowhawk, a very close relative of the North American sharp-shinned hawk, is worth a closer study. The book follows the same outline as Dr. Holstein's previous monographs on the goshawk, *Astur gentilis dubius* (1942) and the honey buzzard, *Pernis apivorus* (1944).

Details of the life-history of the sparrowhawk are discussed in chronological order, first how the winter is spent and about spring migration, next the breeding biology of the

species and finally a chapter on the fall migration. The most valuable part of the book are the detailed studies of the breeding behaviour of sparrowhawks. It was found that sparrowhawks usually return to the nesting territories they have once chosen; a new nest is normally built every year; the interval between the laying of two eggs is two days; clutch sizes average 4 to 5 eggs; the female alone incubates the eggs for 39 to 42 days, reckoned from the laying of the first egg to the hatching of the last young; by thermo-electric measurements it was found that the incubation temperature gradually rises from 23°C to about 36°C in the first 18 days after which it remains fairly constant around 37°C for the remaining part of the incubation period; eggs begin chipping two days before hatching; in the first 12 days of the life of the young the female spends all her time in the nest, prey being brought to her by the male; while the average number of eggs in 94 nests was found to be 4.5, only 2.9 fully fledged young were produced per nest; the young can fly at an age of 26–28 days, but take all their meals on the nest until they are 33–35 days old; the young leave the nesting place when about 55 days old; a total of 518 specimens of prey was brought to one nest during the nesting period; this material contained 4 voles, 1 gallinule, the remaining part being passerines.

Dr. Holstein's book also contains a fine series of photographs of sparrowhawks and it can be recommended to every bird student for its fund of data, clearness of style and presentation and its solution of many problems concerning this shy hawk of the spruce forests.—KAJ WESTERSKOV.

Practice of Wildlife Conservation. Leonard W. Wing. New York, John Wiley and Sons, Inc. xii + 412 pp. 59 figs., many tables. 1951. $5.50.

The physical make-up of this book is excellent. The paper, printing, binding and design are of good quality. The format is attractive: modern but conservative. The language and presentation, while not polished, are clear and direct and there is a minimum of redundance. The photographs and sketches are adequate.

The first disturbing note comes on the dust jacket edges entitled *About the book.* Part of two paragraphs (not written by the author but apparently accepted by him) is as follows, ". . . this book offers a thorough coverage of the entire field: birds, mammals, and fish, along with administration and policy. These features as well as its technical treatment make *Practice of Wildlife Conservation* the perfect text." Modesty undoubtedly prevented further claims.

The text comprises 24 chapters, each about 20 pages in length. Whenever the subject matter extends beyond this limit it is continued in the next chapter under the same heading. The first three are a general attempt to show what field of biological knowledge is employed by game managers, plus an attempt to define terms. The next two deal with techniques. Here in an effort to be all-inclusive many techniques are listed without explanation. The next eleven chapters deal with game species on an ecological and geographic basis, *e.g.* Game Birds of the Forest (Chapter 9), Farm Game Birds and Mammals (Chapter 7). In each category there is a resumé of the life history of the various species. Two chapters are given to fish and fisheries problems. Non-game and rare species are covered in one chapter each. The last four chapters deal with the legal and administrative aspects of conservation.

The author states specifically that the book was written with extra regard for readability and implies that scientific "jargon" would be omitted. This is amusing since in Chapter 2 there are 42 instances where I considered the usage as jargon, and this chapter is not atypical. Oftentimes words are used before they are defined and some are inadequately defined or used without definition, *e.g.* ecology, carrying capacity, Lincoln index, territory. I hasten to add that readability is unimpaired, but understandability may suffer.

The book is designed as a text for students of conservation. In the preface the author claims that his experience indicates that documentation and citation in the text are best *omitted.* One of the reasons given in that "the average student does not have time to hunt widely in the voluminous literature." A student in this or any other field who hopes to become a scholar must take time to do just that. An educational course or system that fails to inculcate this academic discipline defeats one

of the main purposes of higher learning; namely, a critical evaluation of the material taught as fact or theory.

The lack of documentation (except in a single instance, p. 351) makes it difficult if not impossible to tell where the author is drawing on his own work and where he has drawn on the literature. It is also difficult to tell whether any idea is new or old. There are many places in the text which indicate the author is unaware of current developments, as in the discussion of the Pittman-Robertson Act, where the author states that funds are appropriated from a 10 per cent excise tax (though this was changed to 11 per cent in 1940), and where he indicates that maintenance after completion of a development project must be carried on by the state (though the amendment of 1946 provided otherwise).

Most of the information is presented as flat assertions. This kind of presentation might suffice for grade school teaching or even in high school, but it seems doubtful to me that any college student will accept all the facts on face value, or because he loves his teacher. More than likely he will ask "Who said so?", "How do you know?", or "Why is this so?". A user of this text had better know exactly where each assertion is documented in the literature or else have students who do not ask questions.

The game species in the various groupings are listed in a "biology table" where such things as range, weight, number of young, food, etc., are put in tabular form. These tables (six in all) are clear and of great help to the reader. In fact, most of the tables are very good except where percentages on small numbers are carried to two decimal places (Tables 1.1 and 8.1).

There is a surprising lack of information on population dynamics and few specific examples of where and how a management practice has worked successfully. No mention is made of the Wildlife Society relative to its history, purpose, or function.

This amazing statement appears on p. 195, "The coyote has held its own, or even increased, because of its resistance to control." I read this two days after I talked with the Fish and Wildlife Service predator control man at Powder River, Wyoming, who told me that 1080 had so completely eradicated the coyote that for almost a year he had been concentrating on bobcats.

The last four chapters dealing with administration and the legal aspects of conservation (except for the discussion on the Pittman-Robertson Act) are exceptionally good. There is a subtle presentation of legal and administrative history along with the facts. The citation of cases on which legal precedent is based gives stature to these chapters. Workers in the field of wildlife conservation will say amen to the first paragraphs of Chapter 23, which points to the similarity of people and their conservation problems between Canada and the United States. This similarity is not always realized by beginning students of wildlife management.

The 48-page index is superb: few scientific texts can claim one as good.

This book is a very good compendium of information and ideas in the field of wildlife conservation, but it is not a complete coverage of the entire field nor is it the perfect text.—ROBERT A. MCCABE.

Audubon Water Bird Guide. By Richard H. Pough, Doubleday & Company, Inc., Garden City, N. Y. xxviii + 352 pp. illus. $3.50.

This second volume of Pough's bird guide will be welcomed by wildlifers because it covers the groups of birds of eastern North America which are now or have in the past been considered game species, together with the hawks. Although primarily a guide for identification, the book contains much additional useful information; each species has paragraphs on identification, habits, voice, nest, and range.

A surprising amount of information is packed into the volume, a concise style of writing having been assisted by an adroit use of abbreviations. Where known, the incubation period, the period a nestling remains in the nest, and the maximum recorded age of the species, are all presented with abbreviations, so that these three items take less than half a line of text.

Several of the book's features make it particularly useful or convenient. It includes

48 full-page color plates, which present the water, game, and large land birds, frequently in more than one plumage, because there are 458 figures in color for the 258 species. Since the range covered by the book includes an area from southern Texas to Key West and northward, many extra-limital species infrequently illustrated in most familiar bird books are presented here, such as the masked duck, lapwing, and Key West quail dove. Extinct species, like Labrador duck, passenger pigeon, and great auk, are presented in full color and included in the text. While all colored plates are together in the middle of the volume, the plate and text can easily be located, because the plate indicates the text page for each species and vice versa.

The range descriptions give the entire range of the birds, and not merely that in the United States or in North America. The necessarily condensed style, in order to present the tremendous mass of information which is included, may confuse some uninitiated readers, particularly if they do not read the foreword carefully. Reading literally one might not realize that the single figure which is frequently presented for such items as incubation period, number of days nestlings remain in the nest, and occasionally number of eggs, represent averages from which there may be some to considerable variation. Likewise, the "age" which is given for each species where known is a maximum age, attained in nature by very few individuals. Any such misconception, however, would be the fault of reader, and not author, because Pough has carefully explained such matters in his foreword before launching into the species accounts.

The colored illustrations by Don Eckelberry uphold the high standard of quality he established in the land bird volume previously issued, and the 138 line drawings of birds in flight by Earl Poole are both useful and decorative. This is a carefully planned, and skillfully executed volume which reflects credit on author, artists, and publisher, and the fact that it can be mass produced so as to sell for $3.50 is an indication of the increasing interest of Americans in wildlife.—GUSTAV A. SWANSON.

BRIEFER ARTICLES

AN INSTRUMENT FOR TAKING FIELD MEASUREMENTS

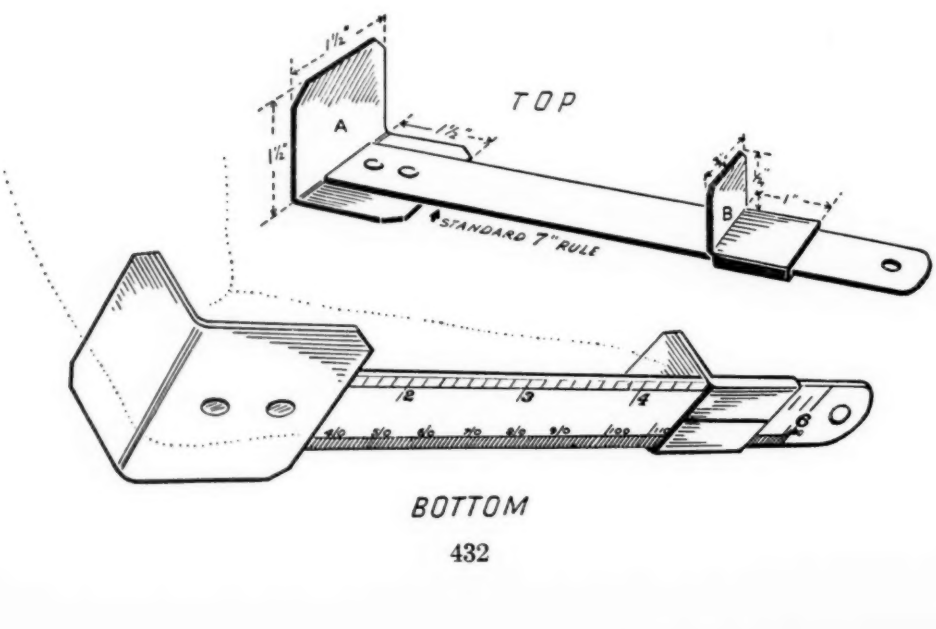
An integral part of Pittman-Robertson Project 26-R (Cottontail Management Study) is taking tarsal measurements of all rabbits trapped in the field. Formerly, measurements were taken by placing the thumb against the end of a steel rule and then placing the heel of the rabbit against the thumb. The tarsus was pressed tightly against the steel rule and a reading was taken at the end of the longest toe nail. It was found extremely difficult to get the same measurement from the same tarsus on successive attempts. Especially was this true of rabbits which were quite active during the measuring process. Because of the difficulties in obtaining accurate measurements, the device illustrated was developed.

A seven-inch steel rule with inch and millimeter markings, 2 pieces of 1/16″ sheet aluminum, 2 copper rivets, and a nut and bolt were used to construct the "tarsal measurer." One piece of aluminum 1½″ x 3″ was bent 1½″ from the end at a 90° angle to form one end of the measurer (piece A). This piece was placed at the end of the rule and two holes were drilled through the aluminum and the rule. It was then riveted to the scale with two copper rivets. Piece B was made from a 1½″ x 1½″ piece of aluminum. A 3/4 inch "tongue" was made by cutting 3/8″ x 1/2″ from each side of one end. This 3/4 inch "tongue" was then bent at a 90° angle to form the upright part of B. The sides were then bent around the scale so that B would be held in place and would slide along the scale. Not shown in the drawing is a nut and bolt which fits through the hole at the end of the rule and keeps B from becoming unattached.

A block of known length was placed on the scale and measured so that the error in workmanship could be determined and used as a corrective figure in future tarsal measurements.

When measuring a rabbit's foot with this device, place the heel against A with the toes extending along the scale toward B. Slide B toward the toes until the perpendicular part contacts the longest toe nail. Take the reading on the millimeter scale on the underside.

Various modifications can be made to this instrument to fit the needs of persons desiring to use it for other medium-sized mammals.—WILMER C. RICHTER, *Pennsylvania Game Commission, Harrisburg, Penna.* Accepted for publication January 4, 1951.



BREEDING SEASON OF THE SONORA WHITE-TAILED DEER

The diminutive Sonora white-tail (*Odocoileus virginianus couesi*) occurs sparingly in southwestern United States, but nearer the center of its range, which is the Sierra Madre Occidental in northwestern Mexico, it is abundant in yellow pine and oak woodland at elevations of 5000 to 8000 feet. During the winter of 1937–38 and again in the summer of 1948, observations were made on the breeding period of this small deer in the Gavilan River basin, 6500 feet elevation, seven miles southwest of Colonia Pacheco, Chihuahua. Up to 1948 this area was relatively wild and undisturbed. Deer, peccaries, wolves and mountain lions lived together in their natural habitat in what appeared to be a balanced predator-prey range relationship (Leopold, Song of the Gavilan, Jour. Wildl. Mgt., 4: 329–332, 1940). Unfortunately this balance will soon be lost with logging and grazing now making inroads on the Gavilan watershed.

In the course of a deer hunt in 1937–38 (Dec. 25 to Jan. 9), two adult bucks were killed, both fat and showing no signs of rut. They weighed 80 and 60 pounds respectively, hog-dressed. At that time our guides, Clarence Lunt and Floyd Johnson, stated that the rut may begin as early as Christmas but the peak of activity usually occurs in mid-January which is considerably later than the rut in northern white-tails.

In the summer of 1948 we had the opportunity to verify that fawning is correspondingly late in Gavilan deer. No fawns or fawn tracks were seen from mid-July when we arrived in the area until mid-August. On July 31 a pregnant doe was collected and the foetus was judged to be two weeks short of full term. Another doe collected August 8 had a foetus nearly ready to drop. The first evidence of a dropped fawn was found in the stomach of a wolf killed August 16. It had recently eaten a new-born fawn which, when removed from the stomach, could be pieced together like parts of a puzzle. There was, however, one extra piece—the ear of an adult deer. Presumably the doe came to the defense of the fawn only to lose an ear for her efforts. A two-day-old fawn was found on August 18. Thereafter fawn tracks were seen with increasing frequency. Peak of fawning in this population, therefore, occurs in mid-August at the appropriate seven-month interval following the rut.

The retarded breeding cycle of Sonora white-tails appears to be correlated with seasonal rainfall. Most of the rainfall in western Chihuahua falls in July, August and September, and the peak of vegetative growth occurs in August. Maximum vegetative growth in most plants occurs about the time they blossom. As a phenological indicator of lushness of growth, a record was kept of first blossoming of all plants encountered (Fig. 1). The start of fawning in 1948 occurred at a time when the plants were at or near their peak of annual growth. This presumably is the most auspicious time for fawns to arrive. Parallel delayed breeding in Mearns quail, wild turkeys and some smaller birds signifies the same influence on timing of breeding.

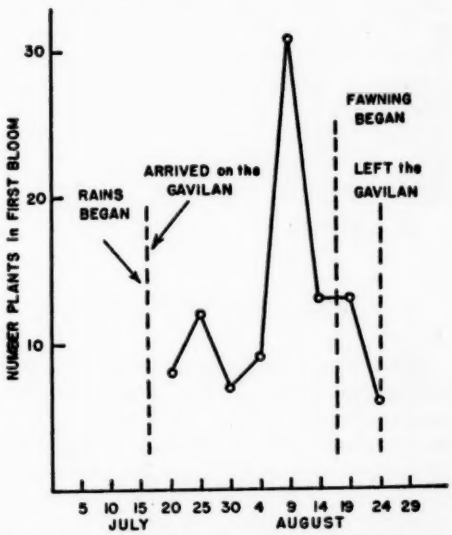


FIG. 1. A record of first blossoms recorded for 99 species of plants growing in the Gavilan basin in the summer of 1948. The deer dropped their fawns in what is probably the peak of vegetative growth, after most plants had started blooming.

In southern New Mexico and Arizona the little white-tails fawn in July (Mearns, Mammals of the Mexican Boundary of the United States, 1907, U. S. Nat. Mus. Bull. 56,

p. 177). The larger races to the north (i.e. Wisconsin, Michigan, New York) drop their fawns in June or even late May. In these northern mesophytic areas temperature rather than precipitation initiates the period of plant growth and hence the time at which conditions are optimum for fawning. We deduce therefore that the exceptionally late breeding of Gavilan white-tails is merely a normal adaptation to vegetative cycles.

Rough sex ratios among the deer were obtained on both trips to the Gavilan. They were:

Year	*Number Deer Classified*	♂♂ : ♀♀
1937–38	186	52 : 100
1948	82	41 : 100

In these counts, yearlings were tallied with adults. No adequate fawn : doe ratios were obtained.

The uneven sex ratio of adult deer could be explained in several ways. First, hunting pressure might be great enough to remove half of the males. This is unlikely since hunting pressure is actually light and, more importantly, there is no indication that local hunting is highly selective for bucks. Secondly, there could be an unavoidable field bias in our observations (e.g. males being more secretive or for some reason not observed as readily as females). Granting the possibility of some error in our tallies, it would hardly explain so great a distortion. Thirdly, natural mortality factors may operate against the bucks. This is possible but if it occurs we do not know how or when. Bucks exhaust their vigor and resistance during the rut and at least in winter may be more subject to predation or other losses than are the females. A moderately distorted sex ratio may be normal in a white-tailed deer population that is in balance with a natural environment which includes predators. Such has been reported among other species of Cervidae occurring in semi-wilderness in Canada (Cowan, Some vital statistics of big game on overstocked mountain range. Trans. N. Amer. Wildl. Conf. 15: 581–588).

To sum up, white-tails of the Gavilan basin breed in mid-January and fawn in mid-August when the summer rains have produced a lush vegetation. The observed sex ratio has remained about one buck to two does over a ten-year period.—ROBERT A. MCCABE, *University of Wisconsin, Madison* (supported by a grant from the Wisconsin Alumni Research Foundation), and A. STARKER LEOPOLD, *Museum of Vertebrate Zoology, Berkeley, California.*

Accepted for publication January 4, 1951.

BREEDING BIRD POPULATIONS OF UPLAND FIELD BORDERS

Woodland edges are found on nearly every field in the Southeast. It is well known that cropland bordering a stand of timber is low in productivity due to shading and the "sapping" of moisture and fertility by the trees. In surveys by the Soil Conservation Service, the unproductive strip adjacent to woodland was found to average 30–35 feet in width. Davison (Jour. Wildl. Mgt. 5(4): 390–394, 1941) pointed out the need for checking erosion on these sites and suggested they be used for wildlife plantings.

The two legumes that have been planted either singly or in combination on field borders in the Southeast are *Lespedeza cuneata* (formerly *L. sericea* and now widely called "sericea") and *L. bicolor*. Neither plant has been considered of particular value to songbirds, but studies are needed to determine all likely wildlife relationships. It was possible to study breeding bird populations on borders improved with sericea in the vicinity of Gadsden, Alabama. These strips might conceivably be feeding areas or provide nesting cover for some species.

For every sericea border studied a comparable control was selected. The control in each pair was similar in all respects to the improved border except that it lacked the sericea planting. Therefore, it was considered that any significant difference in bird populations would reflect the influence of the sericea. Bicolor plantings were not available in this vicinity.

Field work was done on farms in Etowah County in May and June, 1947 and 1948. Observations were made from 6:30 to 11:00 a.m. In this region migrant birds have left by May 1 and summer residents have established territories and begun nesting. Only bright days with average temperatures were used for observations. Some scattered clouds were present on a few days but this was assumed to be insignificant.

The bird population of each border was studied along the field edge on a strip 100 feet wide, extending 50 feet into the field and 50 feet into the woodland. Both borders in a pair were censused on the same mornings with the order reversed on alternate days. Seven improved and 7 control borders were studied each year. Every border was traversed 8 times on foot, making a total of 224 census trips for the entire project. All birds seen and heard were recorded. Details of movements and actions such as adults carrying food, singing males, localized pairs, feeding of young, and all other mating activities were noted. From these observations the numbers of breeding pairs were estimated.

In 1947 all birds were listed on a daily log for individual strips. In 1948 a more precise system was used when numbered cards were tacked on trees dividing the border in 100-foot intervals. Field observations were then plotted on a map (scale 2″ – 100′) of the strip in question.

Table 1 lists the species observed and the type of border on which each was seen. Table 2 summarizes the field work for the two years. The yearly differences in the footage of borders studied resulted from the deletion of three pairs of borders which were not suitable the second year and the substitution of three newly-selected units.

TABLE 1.—SPECIES OBSERVED

Common Name	1947 Improved	1947 Control	1948 Improved	1948 Control
Bluebird	x	x	x	x
Bluejay	x	x	x	x
Bunting, Indigo	x	x	x	x
Cardinal	x	x	x	x
Catbird	x	x	x	
Chat, Yellow-breasted	x	x	x	x
Chickadee, Carolina	x	x	x	x
Crow	x	x		
Cuckoo, sp.			x	
Cuckoo, Black-billed			x	
Cuckoo, Yellow-billed	x	x		x
Dove, Mourning	x	x	x	
Flicker				x
Flycatcher, Acadian	x	x		
Flycatcher, Crested	x		x	
Flycatcher, Least*		x		
Gnatcatcher, Blue-gray	x	x	x	
Goldfinch*	x			
Hawk, Red-tailed			x	
Hummingbird Ruby-throated	x	x	x	
Killdeer			x	
Kingbird				x
Meadowlark	x	x		
Mockingbird	x	x	x	x
Nuthatch, Brown-headed	x	x	x	x
Nuthatch, White-breasted	x			
Oriole, Orchard	x	x		x
Ovenbird				x
Pewee, Wood	x	x	x	x
Phoebe	x			
Quail	x	x	x	x
Robin*	x			
Sparrow, sp.	x		x	x
Sparrow, Bachman's			x	
Sparrow, Chipping	x	x	x	x
Sparrow, English	x			
Sparrow, Field	x	x	x	x
Tanager, Scarlet*		x		
Tanager, Summer	x	x	x	x
Thrasher, Brown	x	x	x	x
Thrush, Wood	x	x	x	x
Titmouse, Tufted	x	x	x	x
Towhee,	x	x	x	x
Vireo, sp.	x			
Vireo, Red-eyed	x	x	x	x
Vireo, White-eyed			x	x
Vireo, Yellow-throated			x	
Warbler, sp.	x			
Warbler, Black and white	x		x	x
Warbler, Blackburnian*	x		x	
Warbler, Canada*				x
Warbler, Hooded			x	x
Warbler, Kentucky			x	x
Warbler, Pine	x	x	x	x
Warbler, Prairie	x	x	x	x
Warbler, Yellow-throated	x		x	x
Woodpecker, Downy	x		x	
Woodpecker, Hairy	x			
Wren, Carolina	x	x	x	x
Yellow-throat	x	x	x	
Unidentified	x	x	x	x

* Not considered a summer resident.

TABLE 2.—SUMMARY OF FIELD WORK ON WOODLAND BORDERS

	1947 Improved	1947 Control	1948 Improved	1948 Control
Total length	7769 ft.	7029 ft.	6830 ft.	4400 ft.
Observation time	1284 min.	1108 min.	1058 min.	886 min.
Total observations	447	283	460	287
Singing males in territories	71	54	60	36
Singing males per 1000 feet	9.1	7.7	8.8	8.1
Estimated breeding pairs	91	67	81	43
Breeding pairs per 1000 feet	11.7	9.5	11.9	9.8

Observation time also varied. In 1947 an average of 165 minutes per 1000 feet was spent on improved borders and 158 minutes per 1000 feet on controls. In 1948 the averages were 155 and 201 minutes for improved and control borders, respectively. This variation should not be reflected in the results as it was assumed in the method that each border was traversed sufficiently to insure that all breeding individuals would be recorded.

Bird observations per 1000-foot units averaged 58 for improved and 40 for control borders in 1947 and 67 and 65, respectively, in 1948. Results in 1947 indicate considerably more activity on improved edges while in 1948 differences were slight. It is inherent in this method that there will be more variability in total observations than in the number of resident breeding pairs. Hence, the most significant figures are those on individuals as given in Table 2.

Year to year records on singing males and breeding pairs appear to be consistent for both improved strips and controls. When they were adjusted to a 1000-foot basis it appeared that improved borders had slightly higher populations. However, in these calculations several reversions occurred, i. e., the improved border did not have the higher population for every pair examined. This indicated inconsistency, and the data were subjected to statistical analysis. The differences between singing male or breeding pair populations on the border types were found to be too small to be significant. If such a difference does exist it is unimportant from the management standpoint. Though the seeding of sericea is regarded as an erosion control measure, this practice cannot be considered as having an important influence on breeding bird populations.

This paper is a contribution from the Patuxent Research Refuge of the Branch of Wildlife Research. The study was a part of the Service program of wildlife investigations on agricultural lands under the supervision of Durward L. Allen. The author is indebted to E. F. Schultz, Jr., Assistant Agronomist, Agricultural Experiment Station, Alabama Polytechnic Institute, Auburn, Alabama, and James B. DeWitt, Chemist, Patuxent Research Refuge, Laurel, Maryland, for assistance with the statistical analysis.—WALTER ROSENE, JR., *U. S. Fish and Wildlife Service, Gadsden, Alabama.* Accepted for publication December 12, 1950.

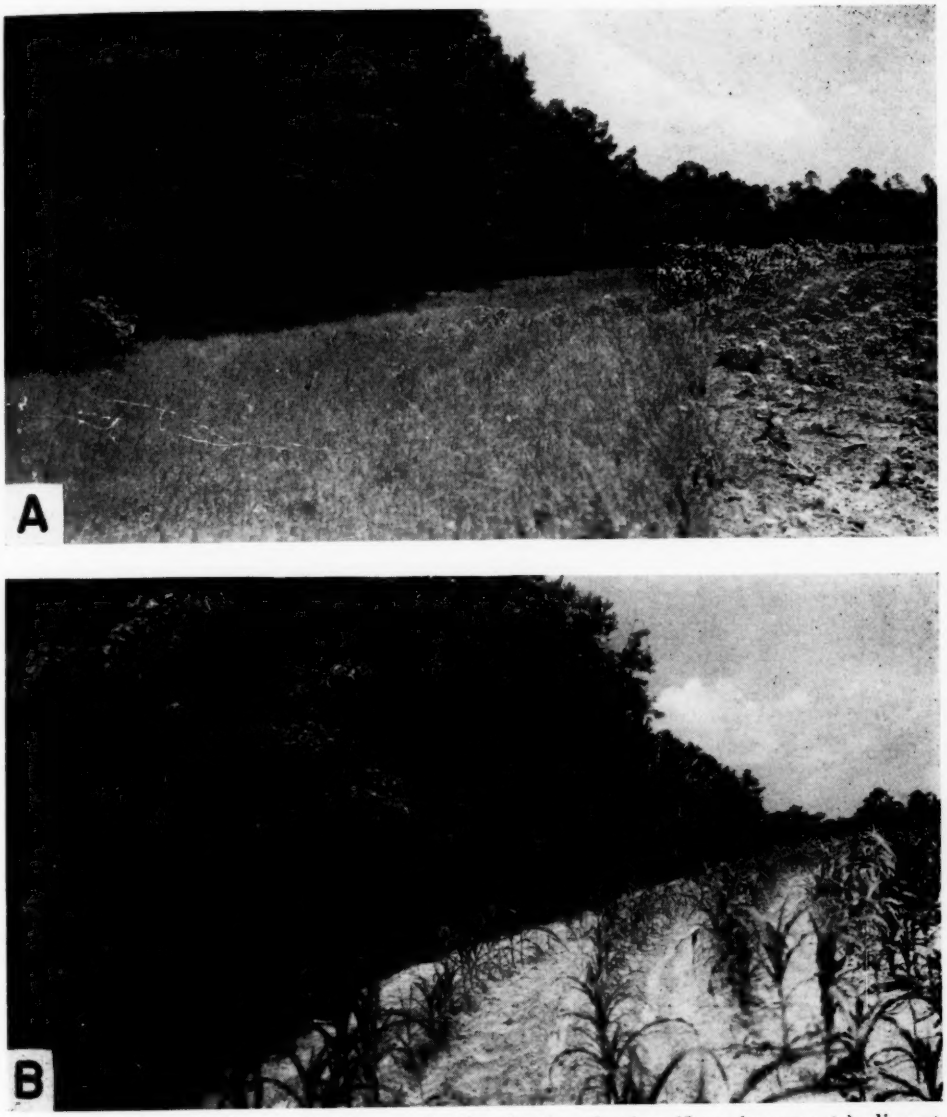


PLATE 14A.—Woodland border improved with a planting of sericea (*Lespedez acuneata*) adjacent to the trees. B.—Control border which is similar to the improved one in all major respects with the exception of the sericea planting. The weak growth of corn is evident next to the trees.

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